TRANSPORTATION LIBRARY

# PUBLIC ROADS

## A JOURNAL OF HIGHWAY RESEARCH

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS

VOL. 19, NO. 8 ▽ OCTOBER 1938

ON U S 60 IN WEST VIRGINIA

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - - - - See page 2 of cover for prices

# PUBLIC ROADS ▸▸▸ *A Journal of Highway Research*

*Issued by the*

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

D. M. BEACH, *Editor*

Volume 19, No. 8 October 1938

*The reports of research published in this magazine are necessarily qualified by the conditions of the tests from which the data are obtained. Whenever it is deemed possible to do so, generalizations are drawn from the results of the tests; and, unless this is done, the conclusions formulated must be considered as specifically pertinent only to described conditions.*

## *In This Issue*

| | Page |
|---|---|
| The Effect of Using a Blend of Portland and Natural Cement on the Physical Properties of Mortar and Concrete | 153 |
| Disposition of State Motor-Fuel Tax Receipts, 1937 | 167 |
| Disposition of State Motor-Vehicle Receipts, 1937 | 168 |
| Disposition of State Motor-Carrier Tax Receipts, 1937 | 169 |
| Disposition of Receipts from State Imposts on Highway Users, 1937 | 170 |

THE BUREAU OF PUBLIC ROADS - - - - - - - - - - - Willard Building, Washington, D. C.

REGIONAL HEADQUARTERS - - - - - - - - - - - - - Federal Building, Civic Center, San Francisco, Calif.

▼

DISTRICT OFFICES

DISTRICT No. 1. Oregon, Washington, and Montana.
Post Office Building, Portland, Oreg.

DISTRICT No. 2. California, Arizona, and Nevada.
Federal Building, Civic Center, San Francisco, Calif.

DISTRICT No. 3. Colorado, New Mexico, and Wyoming.
254 New Customhouse, Denver, Colo.

DISTRICT No. 4. Minnesota, North Dakota, South Dakota, and Wisconsin.
907 Post Office Building, St. Paul, Minn.

DISTRICT No. 5. Iowa, Kansas, Missouri, and Nebraska.
Masonic Temple Building, Nineteenth and Douglas Sts., Omaha, Nebr.

DISTRICT No. 6. Arkansas, Louisiana, Oklahoma, and Texas.
Room 502, United States Courthouse, Fort Worth, Tex.

DISTRICT No. 7. Illinois, Indiana, Kentucky, and Michigan.
South Chicago Post Office Building, Chicago, Ill.

DISTRICT No. 8. Alabama, Georgia, Florida, Mississippi, and Tennessee.
Post Office Building, Montgomery, Ala.

DISTRICT No. 9. Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.
505 Post Office Building, Albany, N. Y.

DISTRICT No. 10. Delaware, Maryland, Ohio, Pennsylvania, and District of Columbia.
Willard Building, Washington, D. C.

DISTRICT No. 11. Alaska.
Room 419, Federal and Territorial Building, Juneau, Alaska.

DISTRICT No. 12. Idaho and Utah.
Federal Building, Ogden, Utah.

DISTRICT No. 14. North Carolina, South Carolina, Virginia, and West Virginia.
Montgomery Building, Spartanburg, S. C.

Because of the necessarily limited edition of this publication it is impossible to distribute it free to any person or institution other than State and county officials actually engaged in planning or constructing public highways, instructors in highway engineering, and periodicals upon an exchange basis. At the present time additions to the free mailing list can be made only as vacancies occur. Those desiring to obtain PUBLIC ROADS can do so by sending $1 per year (foreign subscription $1.50), or 10 cents per single copy, to the Superintendent of Documents, United States Government Printing Office, Washington, D. C.

CERTIFICATE: By direction of the Secretary of Agriculture, the matter contained herein is published as administrative information and is required for the proper transaction of the public business

# THE EFFECT OF USING A BLEND OF PORTLAND AND NATURAL CEMENT ON THE PHYSICAL PROPERTIES OF MORTAR AND CONCRETE [1]

BY THE DIVISION OF TESTS, BUREAU OF PUBLIC ROADS

Reported by W. F. KELLERMANN, Associate Materials Engineer, and D. G. RUNNER, Assistant Materials Engineer

WITHIN the last few years considerable scaling of concrete pavements has resulted from the use of chemical salts in ice treatment in the Northern States. In an effort to combat this condition the New York State highway department began about 4 years ago to experiment with a blend of portland and natural cement for concrete pavement construction.

Preliminary tests made in the laboratory of the New York Department of Public Works indicated that concretes containing blends of portland and natural cements had greater resistance to alternate freezing and thawing in a solution of calcium chloride than had concretes containing only portland cement. These preliminary laboratory experiments were followed by the construction of a number of experimental sections of actual pavements, using portland cements of various chemical compositions and two natural cements, both made in New York State and both readily available commercially.

The Bureau of Public Roads became interested in this work not only from the technical viewpoint but also because of a request from the Division of Highways of the New York Department of Public Works for permission to conduct certain of its field experiments on pavements financed either wholly or in part with Federal funds. It was felt that before approving the use of blended cements on any extended mileage of highway very definite information should be obtained regarding their effect on other essential qualities, such as strength volume change, etc., and, furthermore, that these tests should be made in the laboratory under closely controlled conditions.

This paper reports the results of such a study as well as the results of a series of freezing and thawing tests on specimens taken from certain of the experimental pavements referred to above. The data on laboratory fabricated specimens are presented in two sections, the first dealing with tests of mortars, and the second with concretes. The results of freezing tests on concrete cores are discussed in a third section.

Tests on the mortar specimens included determinations of crushing strength, flexural strength, absorption, density, durability, and volume change. Two portland cements, differing considerably in chemical composition, and two sands of widely different mineral composition were used in this portion of the investigation. Tests on concrete specimens fabricated in the laboratory included determinations of crushing strength, flexural strength, and modulus of elasticity, using the same two portland cements with local fine and coarse aggregate. One brand of natural cement was used in all specimens fabricated in the laboratory.

The freezing tests discussed in the third part of the report were made on cores taken from four of the experimental concrete pavements. Two natural cements as well as portland cements conforming to four different classifications as to compound composition were used in these roads. Core specimens were taken from sections in which straight portland cement was used as well as from sections containing blends in the proportion of 6 parts of portland cement to 1 part of natural cement, and 5 parts of portland cement to 2 parts of natural cement, by weight. These specimens were subjected to alternate freezing and thawing in water and in a 10 percent solution of commercial calcium chloride.

### REPRESENTATIVE MATERIALS USED IN LABORATORY FABRICATED SPECIMENS

The two portland cements included one brand from the Hudson River Valley region, designated as cement A, and one from the Lehigh Valley of Pennsylvania, designated as cement B. Both cements satisfactorily met the requirements for portland cement of the American Society for Testing Materials. The natural cement represented material produced in the northeastern part of the United States and is typical of the old type produced in vertical kilns. The fineness as determined by the Wagner turbidimeter was about the same for both portland cements, but the natural cement had a fineness more nearly corresponding to that of high-early-strength cement. The results of the physical and chemical tests on the three cements are shown in table 1.

Three concrete sands were used in the investigation. Sands A and C were composed essentially of quartz, and sand B consisted essentially of shale and quartz particles with appreciable amounts of limestone, slate, and sandstone. The sieve analyses and physical properties of the three sands and the coarse aggregate used in the tests are given in table 2. The coarse aggregate used in the laboratory fabricated concrete specimens was a limestone of known satisfactory quality and graded uniformly from No. 4- to 1½-inch material.

For the various tests on mortars, each portland cement and blend was used with each sand. Specimens were made using 100 percent portland cement and using two blends, one in which 14 percent and the other in which 28 percent by weight of portland cement was replaced by natural cement. These values correspond to the percentages of natural cement used in the New York experimental roads, which were of the order of 1 sack or 2 sacks in a 7-sack batch, or 14 and 28 percent, respectively.

For each of the portland cements, a sufficient quantity of water was added to the straight portland cement-sand A mixture to give a flow of approximately 90 on

[1] Paper presented at the forty-first annual meeting of the American Society for Testing Materials, Atlantic City, N. J., 1938.

TABLE 1.—*Properties of cements used in laboratory fabricated specimens*

PHYSICAL PROPERTIES

| Item | Cement A | Cement B | Natural cement |
|---|---|---|---|
| Apparent specific gravity | 3.14 | 3.11 | 3.00 |
| Specific surface, cm²/gm | 1,730 | 1,805 | 2,680 |
| Percent retained on No. 200 sieve | 7.1 | 9.6 | 10.5 |
| Normal consistency, percent | 23.7 | 24.0 | 26.0 |
| Time of set, hours: | | | |
| Initial | 3.3 | 2.9 | 1.1 |
| Final | 5.1 | 4.9 | 1.8 |
| Tensile strength, lb. per sq. in.: | | | |
| 7 days | 380 | 370 | 50 |
| 28 days | 445 | 445 | 150 |

CHEMICAL ANALYSES

| Oxides | *Percent* | *Percent* | *Percent* |
|---|---|---|---|
| Silica | 22.41 | 20.80 | 24.91 |
| Alumina | 4.78 | 6.47 | 9.65 |
| Iron | 3.72 | 2.38 | |
| Lime | 64.55 | 63.22 | 33.93 |
| Magnesia | 1.15 | 3.45 | 19.92 |
| Sulphuric anhydride | 1.72 | 1.77 | 1.42 |
| Loss on ignition | 1.37 | 1.47 | 8.55 |

COMPUTED COMPOUND COMPOSITIONS

| Compounds | | | |
|---|---|---|---|
| Tricalcium silicate | 50 | 47 | |
| Dicalcium silicate | 26 | 25 | |
| Tricalcium aluminate | 6 | 13 | |
| Tetracalcium alumino-ferrite | 11 | 7 | |

TABLE 2.—*Properties of aggregates*

SIEVE ANALYSES OF FINE AGGREGATES

| Total retained on— | Sand A | Sand B | Sand C |
|---|---|---|---|
| ¾-inch sieve | 0 | 0 | 0 |
| No. 4 sieve | 2 | 4 | 7 |
| No. 8 sieve | 11 | 21 | 24 |
| No. 16 sieve | 27 | 45 | 39 |
| No. 30 sieve | 49 | 67 | 53 |
| No. 50 sieve | 84 | 87 | 86 |
| No. 100 sieve | 97 | 95 | 97 |
| Fineness modulus | 2.70 | 3.19 | 3.06 |

PHYSICAL PROPERTIES

| Item | Sand A | Sand B | Sand C | Coarse aggregate |
|---|---|---|---|---|
| Absorption, percent | 0.3 | 2.2 | 0.9 | 0.32 |
| Organic matter | [1] | [1] | [1] | |
| Decantation loss, percent | 1.4 | 2.5 | 1.5 | |
| Compressive strength ratio: | | | | |
| 7 days | 140 | 123 | 121 | |
| 28 days | 130 | 124 | 121 | |
| Percentage of wear, Deval | | | | 3.0 |

[1] Satisfactory.

the 10-inch flow table. The same quantity of water was then used in all other mixtures containing this cement. This resulted in slightly lower flows (drier mortars) for the mixtures containing sand B and also somewhat lower flows for the mixtures containing natural cement. All mixtures, however, were plastic and workable, insofar as could be determined when fabricating the test specimens. The consistencies of the various mixes, as determined by the use of the 10-inch flow table, are shown in table 3.

An outline of the various tests made on the mortar specimens follows.

1. Determinations of crushing and flexural strengths of 2-inch cubes and 2- by 3- by 18-inch beams, using a mix of 1:2 by weight. Specimens were cured continuously in water at 70° F., and broken at ages of 7, 28, 90, 180, and 360 days. Duplicate sets of specimens were cured in air (with 7 days initial water cure) and broken at 28, 90, 180, and 360 days. Beam specimens were broken as cantilevers, using portions of the same beam for tests at various ages.

FIGURE 1.—HORIZONTAL COMPARATOR USED IN MEASURING LENGTH CHANGE OF MORTAR BEAMS.

TABLE 3.—*Consistencies of mortars as determined by the 10-inch flow table*

MIXTURES CONTAINING SAND A

| Percentage of portland cement replaced by natural cement | Cement A | | Cement B | |
|---|---|---|---|---|
| | Beams | Cubes | Beams | Cubes |
| 0 | 91 | 93 | 93 | 93 |
| 14 | 87 | 90 | 90 | 89 |
| 28 | 83 | 83 | 88 | 85 |

MIXTURES CONTAINING SAND B

| | | | | |
|---|---|---|---|---|
| 0 | 83 | 83 | 85 | 85 |
| 14 | 79 | 76 | 82 | 80 |
| 28 | 74 | 70 | 79 | 78 |

2. Determinations of tensile strength of briquets containing standard Ottawa sand in a 1:3 mix by weight. Specimens were broken at 7 and 28 days.

3. Tests for volume change on 2- by 3- by 18-inch beams, using a 1:2 mix by weight. One set of specimens was stored in air for 120 days, the other continuously in water at 70° F. for 180 days. As a supplementary portion of this phase of the work, after 180 days of water storage the beams were frozen and thawed for 6 cycles, dried at 120° F. for 4 days, and resaturated in water at 70° F. for 3 days, after which the freezing and thawing cycle was again repeated. In this test measurements of length were made at the conclusion of each 3-day resaturation period. The linear comparator used in all measurements of volume change is shown in figure 1.

4. Miscellaneous tests included absorption and bulk specific gravity tests on 2- by 4-inch cylinders of 1:2 mortar, sodium sulphate soundness tests on 1- by 1- by 6-inch bars, using a mix of 1:5 by weight of Ottawa sand, and autoclave tests on 1- by 1- by 10-inch neat cement bars.

**USE OF BLENDED CEMENTS DECREASED STRENGTH OF MORTARS**

The results obtained in the strength tests of mortars are given in tables 4 to 7, inclusive, and are shown graphically in figures 2 to 5 inclusive. In the figures, the

values have been plotted so as to show on the left the average results for the two sands with each cement and on the right the average results for the two cements with each sand.

Table 4 and figure 2 give the results of crushing tests on specimens continuously water cured. When the results are averaged as in the figure it will be seen that, for each combination of materials, the straight portland cement mixes developed the greatest strengths

TABLE 4.—*Crushing strengths of 2-inch mortar cubes, mix 1:2 by weight, water cured*

CEMENT A—SAND A

| Percentage of portland cement replaced by natural cement | 7 days | | 28 days | | 90 days | | 180 days | | 360 days | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Lb. per sq. in.*[1] | *Per-cent*[2] | *Lb. per sq. in.*[1] | *Per-cent*[2] | *Lb. per sq. in.*[1] | *Per-cent*[2] | *Lb. per sq. in.*[1] | *Per-cent*[2] | *Lb. per sq. in.*[1] | *Per-cent*[2] |
| 0 | 6,180 | 100 | 8,570 | 100 | 9,625 | 100 | 9,910 | 100 | 9,990 | 100 |
| 14 | 5,805 | 94 | 7,360 | 86 | 8,580 | 89 | 9,005 | 91 | 9,320 | 93 |
| 28 | 4,620 | 75 | 6,105 | 71 | 7,255 | 75 | 7,595 | 77 | 8,290 | 83 |
| CEMENT A—SAND B | | | | | | | | | | |
| 0 | 5,000 | 100 | 6,975 | 100 | 8,280 | 100 | 9,125 | 100 | 9,645 | 100 |
| 14 | 5,010 | 100 | 6,555 | 94 | 7,740 | 94 | 8,270 | 91 | 9,245 | 96 |
| 28 | 4,430 | 89 | 5,845 | 84 | 7,190 | 87 | 7,880 | 86 | 8,660 | 90 |
| CEMENT B—SAND A | | | | | | | | | | |
| 0 | 6,400 | 100 | 8,375 | 100 | 9,825 | 100 | 9,665 | 100 | 9,355 | 100 |
| 14 | 5,090 | 80 | 6,710 | 80 | 8,165 | 83 | 8,695 | 90 | 8,620 | 92 |
| 28 | 4,130 | 65 | 5,420 | 65 | 6,920 | 70 | 7,175 | 74 | 7,490 | 80 |
| CEMENT B—SAND B | | | | | | | | | | |
| 0 | 5,015 | 100 | 6,815 | 100 | 7,840 | 100 | 8,620 | 100 | 8,980 | 100 |
| 14 | 4,745 | 95 | 6,140 | 90 | 7,345 | 94 | 7,725 | 90 | 8,590 | 96 |
| 28 | 3,930 | 78 | 5,215 | 77 | 6,645 | 85 | 7,120 | 83 | 7,735 | 86 |

[1] Each value is the average of 15 tests.
[2] Figures indicate percentage of the strength of 100 percent portland cement mixes.

TABLE 5.—*Crushing strengths of 2-inch mortar cubes, mix 1:2 by weight, air cured after 7-day initial water cure*

CEMENT A—SAND A

| Percentage of portland cement replaced by natural cement | 28 days | | 90 days | | 180 days | | 360 days | |
|---|---|---|---|---|---|---|---|---|
| | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] |
| 0 | 8,825 | 100 | 8,870 | 100 | 8,715 | 100 | 9,085 | 100 |
| 14 | 8,155 | 92 | 8,550 | 96 | 8,535 | 98 | 8,865 | 98 |
| 28 | 6,895 | 78 | 7,335 | 83 | 7,540 | 87 | 7,870 | 87 |
| CEMENT A—SAND B | | | | | | | | |
| 0 | 7,205 | 100 | 7,555 | 100 | 7,870 | 100 | 7,105 | 100 |
| 14 | 7,170 | 100 | 7,470 | 99 | 7,780 | 99 | 6,885 | 97 |
| 28 | 6,540 | 91 | 7,100 | 94 | 7,210 | 92 | 6,295 | 89 |
| CEMENT B—SAND A | | | | | | | | |
| 0 | 8,755 | 100 | 8,975 | 100 | 9,040 | 100 | 8,765 | 100 |
| 14 | 7,530 | 86 | 7,980 | 89 | 8,255 | 91 | 8,175 | 93 |
| 28 | 6,290 | 72 | 6,705 | 75 | 7,065 | 78 | 6,920 | 79 |
| CEMENT B—SAND B | | | | | | | | |
| 0 | 7,040 | 100 | 7,425 | 100 | 7,670 | 100 | 7,195 | 100 |
| 14 | 6,700 | 95 | 6,895 | 93 | 7,465 | 97 | 6,525 | 91 |
| 28 | 5,495 | 78 | 5,505 | 74 | 5,825 | 76 | 6,040 | 84 |

[1] Each value is the average of 15 tests.
[2] Figures indicate percentage of the strength of 100 percent portland cement mixes.

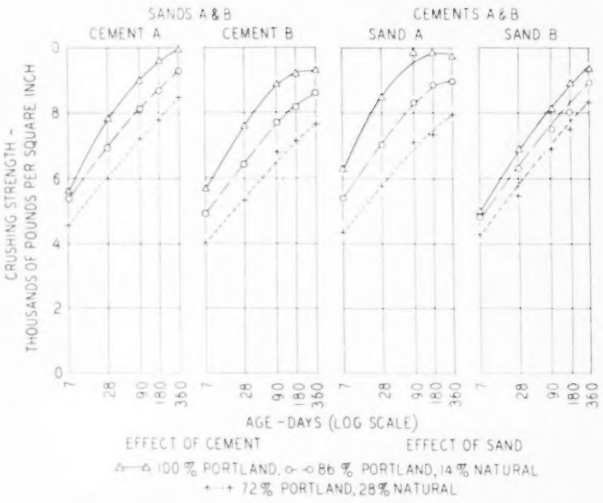


FIGURE 2.—EFFECT OF BLENDING PORTLAND AND NATURAL CEMENT ON THE CRUSHING STRENGTH OF 2-INCH MORTAR CUBES CURED IN WATER.

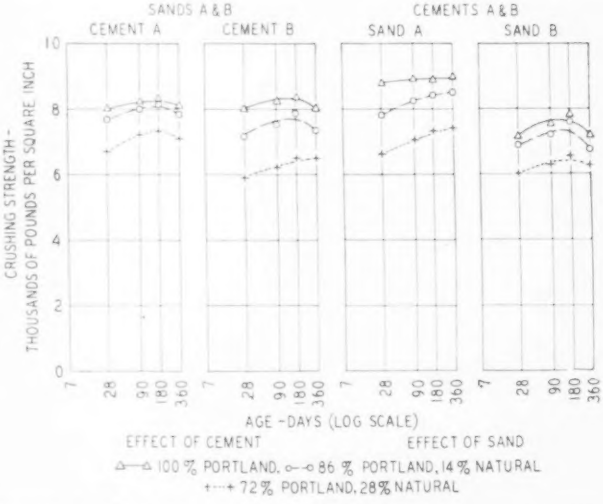


FIGURE 3.—EFFECT OF BLENDING PORTLAND AND NATURAL CEMENT ON THE CRUSHING STRENGTH OF 2-INCH MORTAR CUBES CURED IN AIR.

at all ages. With the exception of the 180- and 360-day values for the straight portland cement mortar in which sand A was used with cements A and B, all mortars exhibited gain in strength from the 7- up to the 360-day periods.

In the left hand portion of figure 2 it may be seen that mortars containing cement A had slightly greater strengths than those containing cement B. The right hand portion of this figure shows the effect of using different sands. In the unblended mix, as well as in the mortar containing 14 percent of natural cement, specimens containing sand A showed greater strengths at all ages. However, in the mixes containing 28 percent of natural cement, the strengths were about the same. In other words, replacing portland cement with natural cement seemed to affect the strength of mortars made with sand A much more than those made with sand B.

The values obtained on air-cured, 2-inch cubes (after 7 days of initial water storage) are given in table 5 and in figure 3. The average values given in the figures

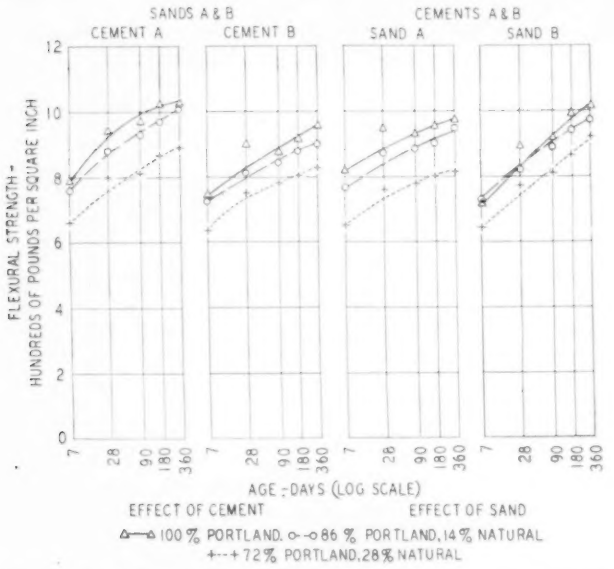
SANDS A & B
CEMENTS A & B
CEMENT A
CEMENT B
SAND A
SAND B
FLEXURAL STRENGTH - HUNDREDS OF POUNDS PER SQUARE INCH
AGE - DAYS (LOG SCALE)
EFFECT OF CEMENT
EFFECT OF SAND
100 % PORTLAND. 86 % PORTLAND, 14 % NATURAL
72 % PORTLAND, 28 % NATURAL

FIGURE 4.—EFFECT OF BLENDING PORTLAND AND NATURAL CEMENT ON FLEXURAL STRENGTH OF 18-INCH MORTAR BEAMS CURED IN WATER.

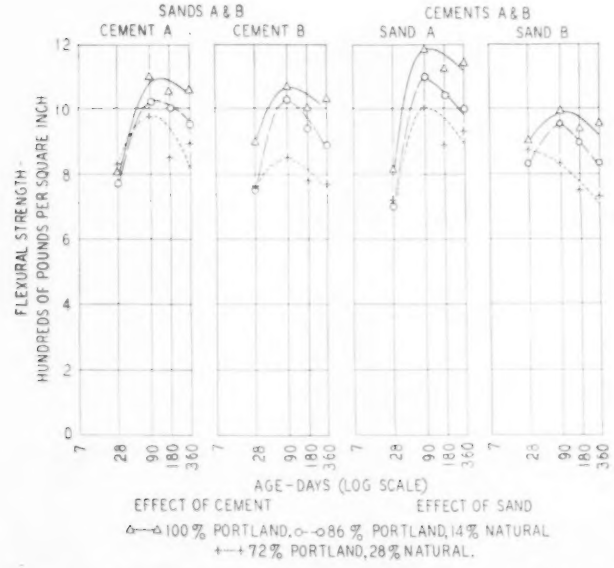
SANDS A & B
CEMENTS A & B
CEMENT A
CEMENT B
SAND A
SAND B
FLEXURAL STRENGTH - HUNDREDS OF POUNDS PER SQUARE INCH
AGE - DAYS (LOG SCALE)
EFFECT OF CEMENT
EFFECT OF SAND
100 % PORTLAND. 86 % PORTLAND, 14 % NATURAL
72 % PORTLAND, 28 % NATURAL.

FIGURE 5.—EFFECT OF BLENDING PORTLAND AND NATURAL CEMENT ON FLEXURAL STRENGTH OF 18-INCH MORTAR BEAMS CURED IN AIR.

show, in all cases, higher strengths for the mixes containing straight portland cement. Comparing figures 2 and 3 it will be noted that the specimens moist-cured 7 days and air-dried for 21 days were in general higher in strength than those cured continuously in water for 28 days. Further air storage, however, resulted in only slight gain in strength at 90 days, with little or no gain thereafter.

Figure 3 shows the effect of the cement and sand upon the crushing strength of the air-dried specimens. Specimens containing cement A exhibited slightly greater strengths in the blends, with the unblended mortars having about the same strength at all ages. Specimens containing sand A showed definitely higher strengths throughout. The most interesting point in connection with this figure is the decrease in strength

TABLE 6.—*Flexural strengths of 18-inch mortar beams, mix 1:2 by weight, water cured*

CEMENT A—SAND A

| Percentage of portland cement replaced by natural cement | 7 days | | 28 days | | 90 days | | 180 days | | 360 days | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] |
| 0 | 850 | 100 | 995 | 100 | 970 | 100 | 1,010 | 100 | 1,030 | 100 |
| 14 | 770 | 91 | 905 | 91 | 940 | 97 | 945 | 94 | 995 | 97 |
| 28 | 660 | 78 | 780 | 78 | 795 | 82 | 825 | 82 | 880 | 85 |
| CEMENT A—SAND B | | | | | | | | | | |
| 0 | 735 | 100 | 900 | 100 | 965 | 100 | 1,045 | 100 | 1,025 | 100 |
| 14 | 755 | 103 | 860 | 96 | 920 | 95 | 985 | 94 | 1,055 | 103 |
| 28 | 660 | 90 | 820 | 91 | 835 | 87 | 915 | 88 | 915 | 89 |
| CEMENT B—SAND A | | | | | | | | | | |
| 0 | 790 | 100 | 905 | 100 | 885 | 100 | 900 | 100 | 915 | 100 |
| 14 | 760 | 96 | 845 | 93 | 835 | 94 | 865 | 96 | 915 | 100 |
| 28 | 650 | 82 | 745 | 82 | 765 | 86 | 790 | 88 | 760 | 83 |
| CEMENT B—SAND B | | | | | | | | | | |
| 0 | 700 | 100 | 890 | 100 | 870 | 100 | 930 | 100 | 1,000 | 100 |
| 14 | 700 | 100 | 795 | 89 | 865 | 99 | 895 | 96 | 885 | 89 |
| 28 | 625 | 89 | 745 | 84 | 800 | 92 | 820 | 88 | 910 | 91 |

[1] Each value is the average of 5 tests.
[2] Figures indicate percentage of the strength of 100 percent portland cement mixes.

TABLE 7.—*Flexural strengths of 18-inch mortar beams, mix 1:2 by weight, air cured*

CEMENT A—SAND A

| Percentage of portland cement replaced by natural cement | 28 days | | 90 days | | 180 days | | 360 days | |
|---|---|---|---|---|---|---|---|---|
| | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] |
| 0 | 720 | 100 | 1,195 | 100 | 1,140 | 100 | 1,180 | 100 |
| 14 | 680 | 94 | 1,110 | 93 | 1,070 | 94 | 1,035 | 88 |
| 28 | 725 | 100 | 1,085 | 91 | 915 | 80 | 970 | 82 |
| CEMENT A—SAND B | | | | | | | | |
| 0 | 885 | 100 | 1,005 | 100 | 950 | 100 | 935 | 100 |
| 14 | 865 | 98 | 930 | 93 | 920 | 97 | 875 | 94 |
| 28 | 930 | 105 | 850 | 85 | 795 | 84 | 805 | 86 |
| CEMENT B—SAND A | | | | | | | | |
| 0 | 905 | 100 | 1,165 | 100 | 1,095 | 100 | 1,100 | 100 |
| 14 | 700 | 77 | 1,080 | 93 | 1,015 | 93 | 970 | 88 |
| 28 | 710 | 79 | 905 | 78 | 855 | 78 | 880 | 80 |
| CEMENT B—SAND B | | | | | | | | |
| 0 | 900 | 100 | 970 | 100 | 915 | 100 | 975 | 100 |
| 14 | 800 | 89 | 970 | 100 | 860 | 94 | 800 | 82 |
| 28 | 810 | 90 | 810 | 83 | 705 | 77 | 655 | 67 |

[1] Each value is the average of 5 tests.
[2] Figures indicate percentage of the strength of the 100 percent portland cement mixes.

caused by the replacement of 28 percent of the portland cement with natural cement. The strengths obtained with this combination ran about 1,000 to 2,000 pounds per square inch lower than those of the straight portland cement mixes for the different cements and sands.

The effect of blending portland and natural cement upon the flexural strength of water-cured mortar beams is shown in table 6 and in figure 4. It will be noted that when the results are averaged as in figure 4, for

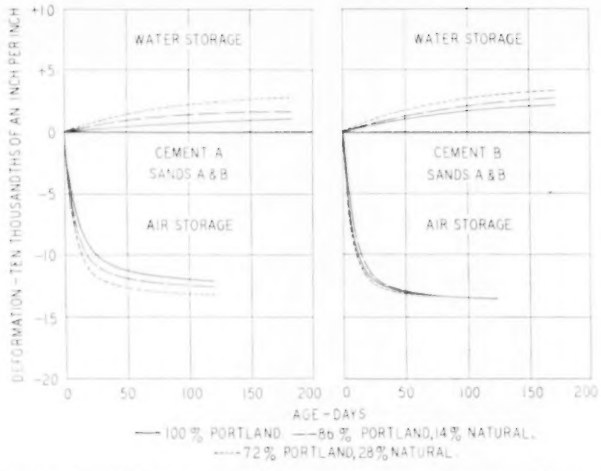


FIGURE 6.—EFFECT OF BLENDING PORTLAND AND NATURAL CEMENT ON VOLUME CHANGE OF 18-INCH MORTAR BEAMS.

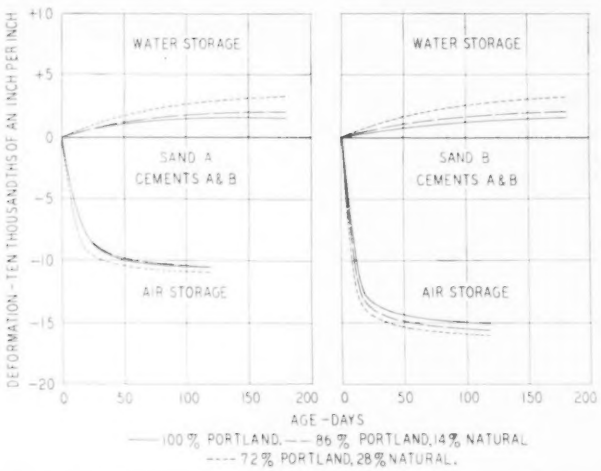


FIGURE 7.—EFFECT OF BLENDING PORTLAND AND NATURAL CEMENT ON VOLUME CHANGE OF 18-INCH MORTAR BEAMS.

each combination of materials, the straight portland cement mixes, with a single exception, produced the greatest strengths at all ages. As in the water-cured compression specimens, the gain in strength with age was fairly uniform. However, the reduction in strength caused by blending was not proportional to the amount of natural cement used, the 28-percent replacement causing a proportionately greater reduction than the 14-percent replacement. Cement A in general produced greater strengths for all combinations of materials than did cement B.

The results of flexure tests on air-cured beams are given in table 7 and in figure 5. It will be observed that here also for each combination of materials, with a single exception, the straight portland cement mixes produced the greatest strengths at all ages. With few exceptions the highest strengths were obtained at 90 days, all mixes showing retrogression after that period. In every case the strengths at 90 days were higher than those of the corresponding water-cured specimens.

The effect of blending portland and natural cement upon volume change of 18-inch mortar beams in continuous water storage is shown graphically in the upper portion of figures 6 and 7. The changes are shown in 0.0001 inch per inch at the ages indicated on the abscissas. It will be noted from the figures that blends containing 28 percent of natural cement had the greatest expansion at 180 days, and that the straight portland cement mixes for all combinations exhibited the least expansion. It is of interest to note (fig. 6) that specimens containing cement B had slightly greater expansions for both blended and unblended mixtures than those containing cement A. However, as will be seen from figure 7, changing the sand had very little effect upon volume change.

### MORTAR BEAMS SUBJECTED TO ACCELERATED WEATHERING TESTS

Volume changes resulting from continuous air storage are shown in the lower portions of figures 6 and 7. The treatment of these beams consisted of storage for 24 hours in the moist closet, at the end of which time an initial reading was taken, followed by continued storage in laboratory air. During the period from 90 to 120 days the beams were placed in a cabinet in which the air was dried with calcium chloride to decrease further the amount of moisture in the specimens. As expected, all beams showed slightly increased shrinkage during this period.

Beams containing sands A and B and cement A had approximately the same amount of shrinkage as those containing cement B (fig. 6). However, specimens containing cements A and B and sand B had shrinkages at 120 days about 50 percent greater than those containing sand A (fig. 7). The figures show that although the initial shrinkage was somewhat greater in specimens containing the blended cements, the total shrinkage at the end of 120 days of continuous air storage was about the same.

The mortar beams from the continuous water storage series were measured for length at the end of 180 days, and then subjected to 15 rounds of the following accelerated weathering treatment. Each round required 13 days for completion and consisted of 6 cycles of freezing and thawing, each 24 hours in duration, followed by drying for 4 days in an electric oven at 120° F., and resaturation for 3 days in water at 70° F. Readings were taken on each beam at the end of the resaturation period and were discontinued at the end of the fifteenth round, at which time surface disintegration of the specimens had progressed to a point which affected the accuracy of the readings because of loosening of the gage points. Unit length changes at the end of the first, third, sixth, ninth, twelfth, and fifteenth rounds are shown in figures 8 and 9. Here the data have been averaged in the same manner as in the previous figures so as to bring out the effect of variations in the cement and sand.

Several points in connection with these figures are of interest. In the first place, all specimens showed an initial contraction followed by expansion up to the fifteenth round. The amount of initial contraction seemed to have been affected greatly by the combination of materials used, being greatest for the combinations involving cement A with the two sands (fig. 8) and sand B with the two cements (fig. 9). The combinations involving sand A with cements A and B showed very little initial contraction. This effect may have resulted from the drying cycle which was introduced. Drying at 120° F. for 4 days undoubtedly induced high shrinkage in the cement paste, subjecting the particles of aggregate to high compressive stress. It is possible that the difference in the ability of the sands to resist this stress without permanent deforma-

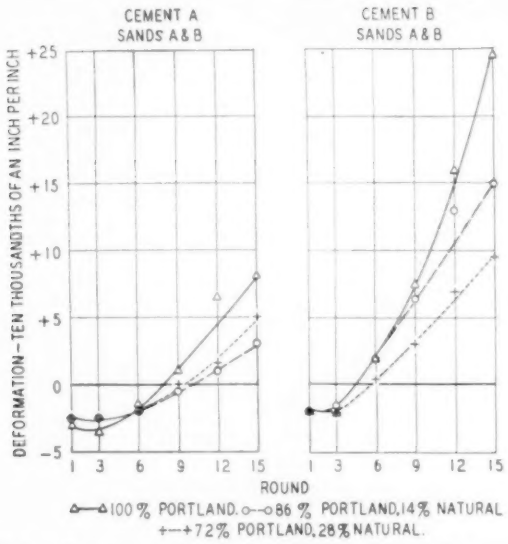


FIGURE 8.—EFFECT OF FREEZING AND THAWING, FOLLOWED BY DRYING, COOLING, AND RESATURATION ON VOLUME CHANGE OF MORTAR BEAMS.

tion may have accounted for the residual shrinkage observed in the specimens containing sand B, which was composed of comparatively low-strength material.

The quartz particles composing sand A may have possessed sufficient strength to resist the shrinkage stresses without permanent deformation, so that the specimens when resaturated returned practically to their original length. The accumulated effect of this action may account also for the relatively small expansions which were observed for specimens containing sand B as compared to the expansions shown by specimens containing sand A.

It will be observed also that, without exception, specimens containing the blended cement showed lower expansions than the corresponding specimens containing only portland cement. It is usually assumed, insofar as expansion is concerned, that repeated freezing and thawing produces a gradually expanding paste, resulting in the eventual disintegration of the specimen. On this basis, the use of the blended cements may be considered beneficial. However, visual examination of the specimens as the test proceeded failed to reveal any consistent difference in appearance at any stage between the specimens containing the blended cements and those containing the straight portland cement. So far as could be determined by visual inspection of the surface, all of the specimens failed at about the same rate. All were badly exfoliated or surface pitted by the end of the fifteenth round and apparently possessed little strength.

### BLENDING INCREASED RESISTANCE OF MORTARS TO SULPHATE ACTION

The effect of replacements with natural cement on the tensile strength of 1:3 Ottawa sand briquets is shown in table 8. It is of interest to note that, for both cements at 28 days, the specimens containing 14 percent of natural cement had very nearly the same strengths as the straight portland cement mortars. The strengths at 28 days of specimens containing 28 percent of natural cement were approximately 90 percent of the strengths of the straight portland cement mortars.

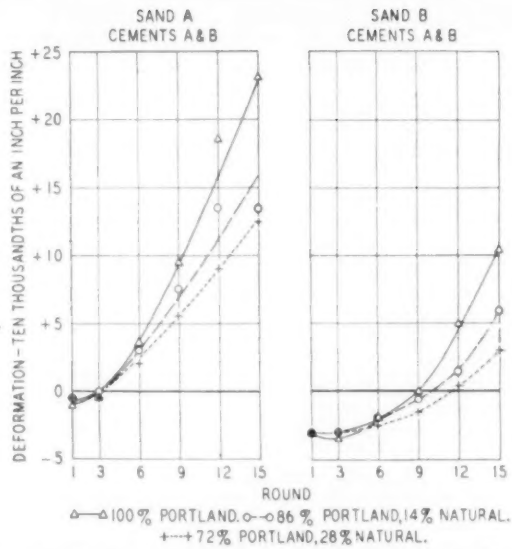


FIGURE 9.—EFFECT OF FREEZING AND THAWING, FOLLOWED BY DRYING, COOLING, AND RESATURATION ON VOLUME CHANGE OF MORTAR BEAMS.

TABLE 8.—*Tensile strengths of briquets, mix 1:3, standard Ottawa sand*

| Percentage of portland cement replaced by natural cement | Cement A | | | | Cement B | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 days | | 28 days | | 7 days | | 28 days | |
| | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] | *Lb. per sq. in.*[1] | *Percent*[2] |
| 0 | 390 | 100 | 455 | 100 | 390 | 100 | 450 | 100 |
| 14 | 370 | 95 | 450 | 99 | 360 | 92 | 440 | 98 |
| 28 | 345 | 88 | 405 | 89 | 330 | 85 | 405 | 90 |

[1] Each value is the average of 15 tests.
[2] Figures indicate percentage of the strength of 100 percent portland cement mixes.

The effect of blending the cements upon the bulk specific gravity and absorption of mortar specimens is shown in table 9. Cylinders 2 inches by 4 inches in size of 1:2 mortar, after 24 hours in moist air, were stored in water at 70° F. and the bulk specific gravity and absorption determined after 7 and 28 days by first determining the saturated-surface dry weights of the specimens in air and in water and then drying to constant weight. It will be observed that blending with natural cement lowered the bulk specific gravity and increased the absorption in all cases. The decrease in density which is indicated by these tests may have been the result of a slight increase in the air voids brought about by the use of natural cement. Other tests have indicated that air voids in concrete are increased somewhat by using blends.

Bars 1 by 1 by 6 inches long, using a 1:5 standard Ottawa sand mortar, and with 0, 14, and 28 percent of the portland cement replaced with natural cement, were fabricated and stored for 6 days in water at 70° F. At the end of this period the bars were measured for length and then immersed in a 10-percent solution of sodium sulphate. After 21 days of continuous storage in this solution at 70° F., they were again measured for length. The amount of expansion was read to 0.001 inch. The results are shown in figure 10 (left panel). Each value is the average of three tests. It will be noted that specimens containing cement B showed greater expansion in all cases than those con-

TABLE 9.—*Bulk specific gravity and absorption of 2 by 4-inch mortar cylinders, mix 1:2 by weight, water cured*

| Percentage of portland cement replaced by natural cement | Bulk specific gravity [1] | | | | Percentage absorption [1] | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 days | | 28 days | | 7 days | | 28 days | |
| | | Percent [2] | | Percent [2] | | Percent [2] | | Percent [2] |
| **CEMENT A—SAND A** | | | | | | | | |
| 0 | 2.10 | 100 | 2.12 | 100 | 9.52 | 100 | 9.23 | 100 |
| 14 | 2.07 | 99 | 2.09 | 99 | 9.89 | 104 | 10.01 | 108 |
| 28 | 2.03 | 97 | 2.04 | 96 | 10.32 | 108 | 10.59 | 115 |
| **CEMENT A—SAND B** | | | | | | | | |
| 0 | 2.09 | 100 | 2.10 | 100 | 10.49 | 100 | 10.32 | 100 |
| 14 | 2.07 | 99 | 2.08 | 99 | 10.84 | 103 | 10.73 | 104 |
| 28 | 2.04 | 98 | 2.05 | 98 | 11.34 | 108 | 11.19 | 108 |
| **CEMENT B—SAND A** | | | | | | | | |
| 0 | 2.07 | 100 | 2.11 | 100 | 10.03 | 100 | 9.98 | 100 |
| 14 | 2.05 | 99 | 2.06 | 98 | 10.66 | 106 | 10.62 | 106 |
| 28 | 2.02 | 98 | 2.02 | 96 | 11.27 | 112 | 11.40 | 114 |
| **CEMENT B—SAND B** | | | | | | | | |
| 0 | 2.09 | 100 | 2.07 | 100 | 10.95 | 100 | 10.76 | 100 |
| 14 | 2.04 | 98 | 2.06 | 100 | 11.34 | 104 | 11.11 | 103 |
| 28 | 2.01 | 96 | 2.04 | 99 | 11.73 | 107 | 11.57 | 108 |

[1] Each value is the average of 3 tests.
[2] Figures indicate percentage of the corresponding values for 100 percent portland cement mixes.

taining cement A, and also that blending with natural cement reduced the amount of expansion in both cases. These tests seem to indicate that blending with natural cement increases resistance to the action of sodium sulphate solutions.

The expansions of neat cement bars exposed for 3 hours at 420° F. in the autoclave are shown in the right panel of figure 10. In both cases, the replacement of 14 and 28 percent of portland cement by natural cement resulted in increased expansion. It will be noted, however, that cement B, unblended, showed considerably greater expansion than cement A with a 28 percent replacement of natural cement. The relatively high expansions shown by cement B may possibly be associated with the higher magnesia and greater $C_3A$ content of this cement. (See table 1.)

The same two portland cements and the same natural cement that were used in the mortar tests were combined with a local fine and coarse aggregate in fabricating the concrete specimens. The characteristics of the aggregates are shown in table 2. Sand C was used in the concrete tests. The coarse aggregate was uniformly graded from No. 4 to 1½-inch. Two blends were used, one with 14 percent and the other with 28 percent of natural cement as in the mortar tests.

A typical concrete paving mix containing 6 sacks of cement per cubic yard with sufficient water for a 2½-inch slump was used. This resulted in a net water-cement ratio by volume of approximately 0.75.

Although the tests made on the mortars showed that the consistency of the mix was affected somewhat by the substitution of natural cement for portland cement, the slump of the concrete containing the blends was the same as that obtained with the straight portland cement. However, in manipulating the concrete it was found that the blended cement mixtures had a stickiness which was not apparent in mixtures containing the straight portland cement.

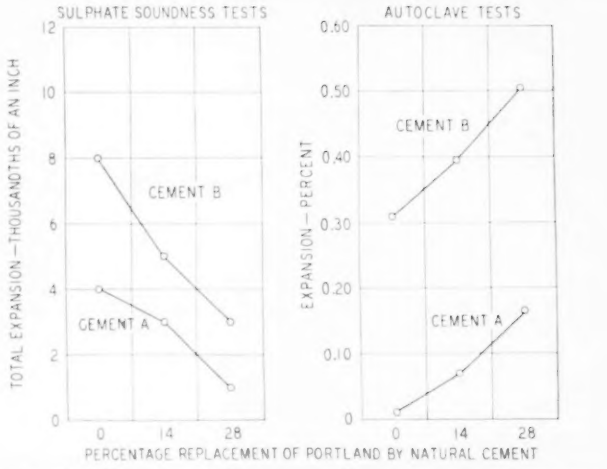


FIGURE 10.—EFFECT OF BLENDING PORTLAND AND NATURAL CEMENT UPON VOLUME CHANGE IN SULPHATE SOLUTION AND IN THE AUTOCLAVE.

### USE OF BLENDED CEMENTS SLIGHTLY DECREASED STRENGTH OF CONCRETE

Flexure tests were made on beams 6 by 6 by 21 inches in size, loaded at the third points of an 18-inch span. Compression tests as well as measurements for modulus of elasticity, using a Martens extensometer, were made on 6-inch by 12-inch cylinders. Five specimens were made for each test condition and tests were made at 7, 28, 90, 180, and 360 days. All specimens were stored continuously in moist air at 70° F. until tested.

The results of the tests for strength and modulus of elasticity on laboratory fabricated concrete specimens are shown in table 10 and are shown graphically in figure 11.

Referring to the data for cement A (table 10 and left panel of fig. 11), it will be observed that there was a gradual increase in crushing strength with age for specimens containing the unblended as well as the blended cement. Blending with natural cement decreased the average strength at all ages about 1 percent in the specimens containing 14 percent of natural cement and about 8 percent in the specimens containing 28 percent of natural cement. Similar data for cement B are shown in the next panel to the right. In the specimens containing straight portland cement it will be observed that the same order of strengths was obtained as with cement A. However, in specimens with the blended cements as compared to the specimens with straight portland cement, the reduction in strength was more marked, the corresponding figures being 7 percent for the 14 percent blend and 17 percent for the 28 percent blend.

It is interesting to observe that specimens containing the 14 percent blend for both cements A and B exhibited higher strengths at 360 days than the corresponding straight portland cement specimens. This was due to the fact that the straight portland cement concretes showed no increase in strength beyond the 180-day period for cement A, while for cement B no increase was observed after the 90-day period. On the other hand, the concrete containing the blended cements showed a fairly uniform increase in strength up to 360 days.

Flexural strengths of the concrete specimens are shown also in table 10 and are plotted in the two center panels of figure 11. For each cement the specimens containing the 14 percent blend had strengths com-

TABLE 10.—*Effect of blending portland and natural cements on crushing and flexural strengths and modulus of elasticity*

CRUSHING STRENGTH—CEMENT A

| Percentage of portland cement replaced by natural cement | Test results at age indicated [1] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 7 days | | 28 days | | 90 days | | 180 days | | 360 days | |
| | *Lb. per sq. in.* | *Per-cent* [2] | *Lb. per sq. in.* | *Per-cent* [2] | *Lb. per sq. in.* | *Per-cent* [2] | *Lb. per sq. in.* | *Per-cent* [2] | *Lb. per sq. in.* | *Per-cent* [2] |
| 0 | 3,730 | 100 | 5,510 | 100 | 6,190 | 100 | 6,650 | 100 | 6,660 | 100 |
| 14 | 3,860 | 103 | 5,270 | 96 | 6,010 | 97 | 6,470 | 97 | 6,830 | 103 |
| 28 | 3,430 | 92 | 4,750 | 86 | 5,870 | 95 | 6,080 | 91 | 6,480 | 97 |

MODULUS OF RUPTURE—CEMENT A

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 600 | 100 | 683 | 100 | 777 | 100 | 858 | 100 | 831 | 100 |
| 14 | 612 | 102 | 697 | 102 | 777 | 100 | 845 | 98 | 857 | 103 |
| 28 | 542 | 90 | 631 | 92 | 742 | 95 | 801 | 93 | 853 | 103 |

MODULUS OF ELASTICITY—CEMENT A

| | *1,000 lb. per sq. in.* | | *1,000 lb. per sq. in.* | | *1,000 lb. per sq. in.* | | *1,000 lb. per sq. in.* | | *1,000 lb. per sq. in.* | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5,272 | 100 | 6,047 | 100 | 6,490 | 100 | 6,785 | 100 | 7,102 | 100 |
| 14 | 5,170 | 98 | 5,947 | 98 | 6,670 | 103 | 6,735 | 99 | 7,432 | 105 |
| 28 | 5,312 | 101 | 5,557 | 92 | 6,268 | 97 | 6,285 | 93 | 6,628 | 93 |

CRUSHING STRENGTH—CEMENT B

| | *Lb. per sq. in.* | | *Lb. per sq. in.* | | *Lb. per sq. in.* | | *Lb. per sq. in.* | | *Lb. per sq. in.* | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 3,990 | 100 | 5,640 | 100 | 6,450 | 100 | 6,310 | 100 | 6,480 | 100 |
| 14 | 3,700 | 93 | 5,000 | 89 | 5,760 | 89 | 5,960 | 94 | 6,530 | 101 |
| 28 | 3,190 | 80 | 4,330 | 77 | 5,250 | 81 | 5,670 | 90 | 5,730 | 88 |

MODULUS OF RUPTURE—CEMENT B

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 620 | 100 | 677 | 100 | 781 | 100 | 783 | 100 | 821 | 100 |
| 14 | 577 | 93 | 698 | 103 | 753 | 96 | 820 | 105 | 859 | 105 |
| 28 | 542 | 87 | 580 | 86 | 716 | 92 | 801 | 102 | 788 | 96 |

MODULUS OF ELASTICITY—CEMENT B

| | *1,000 lb. per sq. in.* | | *1,000 lb. per sq. in.* | | *1,000 lb. per sq. in.* | | *1,000 lb. per sq. in.* | | *1,000 lb. per sq. in.* | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5,225 | 100 | 6,083 | 100 | 6,420 | 100 | 6,638 | 100 | 6,970 | 100 |
| 14 | 5,065 | 97 | 5,810 | 96 | 6,178 | 96 | 6,465 | 97 | 7,070 | 101 |
| 28 | 5,030 | 96 | 5,623 | 92 | 6,018 | 94 | 6,330 | 95 | 6,408 | 92 |

[1] Each value for crushing strength and modulus of rupture is the average of 5 tests. Each value for modulus of elasticity is the average of 4 tests.
[2] Figures indicate percentage of the strength of 100 percent portland cement mixes.

parable to those obtained with the straight portland cement specimens. Specimens with the 28 percent blend had strengths that averaged about 95 percent of those of the straight portland cement specimens. It is to be observed also that for both portland cements the blended cement concrete showed higher strength ratios in flexure than in compression.

Results of tests for modulus of elasticity are shown in the two right panels of figure 11. These results are also included in table 10. Here again the addition of the natural cement is reflected in the somewhat lower values obtained with specimens containing the blended cements.

In general, it may be said that the values obtained in flexure and modulus of elasticity for the specimens containing the 28 percent blend were about 95 percent of those obtained for the specimens containing the straight portland cements. The strength ratios of specimens in compression were not the same for both cements, specimens containing cement B giving an average ratio of 83 percent, which was about 10 percent lower than that obtained for specimens containing cement A. Comparing the results of tests on concrete specimens with the corresponding results of tests on mortar specimens, it will be observed that replacement with the natural cement had a much greater effect on mortar strength than on concrete strength. This would, of course, be expected because of the higher cement content in the mortar specimens.

### FREEZING AND THAWING TESTS MADE ON PAVEMENT CORES

The results of freezing and thawing tests on cores taken from four experimental projects in New York State are given in this portion of the report. On each of these projects specimens of straight portland cement concrete and blended cement concrete were taken from sections containing cement conforming to each of the four classifications as to compound composition given in table 11.

Natural cement of the brand used in the laboratory tests already described was used on two of the projects. The other two contained natural cement from another mill in New York State. A 6:1 blend was used on two of the projects, a 5:2 blend on the other two.

TABLE 11.—*Classification of four cements as to compound composition*

| Specification designation | Tricalcium aluminate $C_3A$ (percent) | Tricalcium silicate $C_3S$ (percent) |
|---|---|---|
| 935 | Not over 9 | Not over 35. |
| 950 | Not over 9 | Between 48 and 52. |
| 1439 | Not less than 14 | Not over 39. |
| 1450 | Not less than 14 | Between 48 and 52. |

This portion of the work was done for the purpose of testing specimens of concrete which had been subjected to the usual field manipulation during placing in order to study the effects of the "bleeding" or "water-gain" which frequently occurs during the finishing operation. This action results in the accumulation of an excess amount of water in the top surface of the pavement, leaving a weak, porous layer which is lacking in resistance to the disintegrating effects of ice and chemical salts.

In a preliminary series of freezing and thawing tests made on full depth cores it was found that disintegration was confined almost entirely to the top 2 inches of the specimen. Because of this, and also to facilitate performance of the test, it was decided to study the effect of the blend by testing the upper portion of the concrete only. Disks 2 inches thick were sawed from the tops of the cores. One set of these disks was alternately frozen and thawed in a 10 percent solution of calcium chloride, the other set in plain water. In addition, a few tests were made to determine the resistance of similar disks sawed from the lower surface of the cores.

It was found desirable in this work to use a minimum amount of the chloride solution and to freeze rapidly in order to keep the solution from separating into layers of different density. This was accomplished by using close-fitting containers and immersing these containers in the brine solution of the refrigerator. The minimum temperature obtained was approximately −10° F., one complete cycle of freezing and thawing being performed each day. The time required to lower the temperature of the specimen to this minimum was approximately 10 hours. The calcium chloride solution was changed after 10 cycles of freezing and thawing. These time-temperature relations applied to freezing both in chloride and in water.

Periodic examinations were made of the specimens, this examination consisting of weight loss determina-

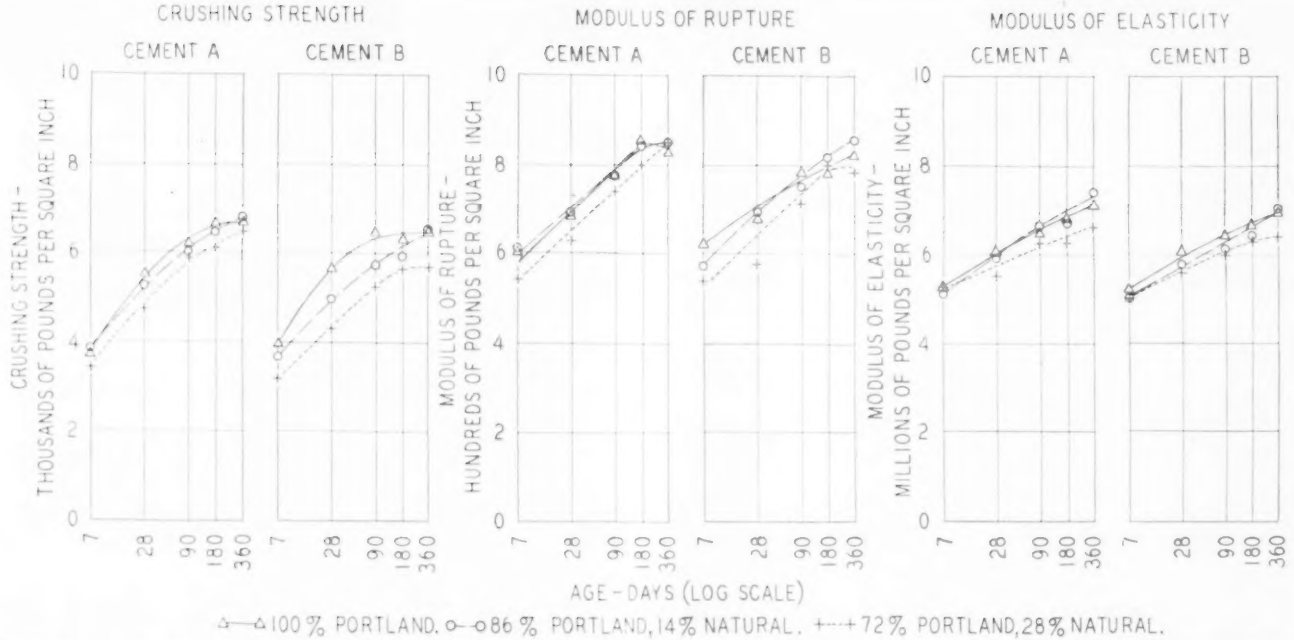
CRUSHING STRENGTH
MODULUS OF RUPTURE
MODULUS OF ELASTICITY
CEMENT A
CEMENT B
CRUSHING STRENGTH - THOUSANDS OF POUNDS PER SQUARE INCH
MODULUS OF RUPTURE - HUNDREDS OF POUNDS PER SQUARE INCH
MODULUS OF ELASTICITY - MILLIONS OF POUNDS PER SQUARE INCH
AGE - DAYS (LOG SCALE)
△—△ 100 % PORTLAND. o—o 86 % PORTLAND, 14 % NATURAL. +—+ 72 % PORTLAND, 28 % NATURAL.

FIGURE 11.—EFFECT OF BLENDING PORTLAND AND NATURAL CEMENT ON STRENGTH AND MODULUS OF ELASTICITY OF CONCRETE.

tions and visual inspections. It was found that the weight losses of the 2-inch disks were meaningless. For instance, a specimen which had not lost more than 2 percent in weight would become unsound and disintegrate. While some scaling of the surface developed, unsoundness in general was caused by failure of the bond between the cement and aggregate, resulting in the eventual disintegration of the entire specimen.

For each project and for each type of freezing there were two groups of 8 specimens each. In one group there were 4 pairs of specimens containing straight portland cement and 4 pairs containing the same portland cements blended with natural cement in the proportion of either 6:1 or 5:2. The 4 pairs of specimens in each group represented concrete containing the 4 classes of portland cement mentioned above.

In order to evaluate the resistance to freezing and thawing, the individual specimens were examined at various intervals and rated in accordance with their appearance and ring when struck with a hammer. A specimen which was entirely sound was given a rating of 12½. An unsound specimen was rated at 2½, while a specimen which appeared to be between these two conditions was considered as questionable and was given a rating of 7½. Any specimen which had disintegrated was given a rating of zero. If all of the specimens of a particular group were sound the rating would be 100. On the other hand, if all of the specimens were disintegrated, the rating would be zero. By this method of rating, the results obtained with the four cements used on each project were averaged for comparison with the results obtained with the same portland cements blended with natural cement. This procedure was decided upon after a study of the individual results had failed to reveal any consistent relation between the composition of the portland cement and its resistance to freezing and thawing either when used straight or when blended. With a few exceptions, concrete made from portland cements conforming to the various composition classifications, when used on a given job, behaved about alike insofar as resistance to freezing and thawing was concerned.



### BLENDED SPECIMENS MOST RESISTANT TO FREEZING IN CALCIUM CHLORIDE SOLUTION AND WATER

The ratings of the several groups of specimens after 35 alternations in a 10-percent solution of calcium chloride as well as the corresponding ratings when frozen in water for various periods up to 150 alternations, are given in table 12. The appearance of each individual specimen at the end of 35 alternations in calcium

TABLE 12.—*Resistance of core specimens to freezing and thawing*

| Blend [1] | Rating [2] at number of freezing and thawing cycles indicated | | | | | |
|---|---|---|---|---|---|---|
| | 35 cycles in calcium chloride | 35 cycles in water | 50 cycles in water | 75 cycles in water | 100 cycles in water | 150 cycles in water |
| **PROJECT A** | | | | | | |
| 7–O | 0 | 45 | 10 | 0 | 0 | 0 |
| 6–1G | 90 | 95 | 90 | 90 | 90 | 90 |
| **PROJECT B** | | | | | | |
| 7–O | 25 | 50 | 30 | 25 | 25 | 25 |
| 5–2G | 100 | 100 | 100 | 100 | 100 | 100 |
| **PROJECT C** | | | | | | |
| 7–O | 40 | 30 | 5 | [3] 0 | 0 | 0 |
| 6–1H | 15 | 25 | 10 | [4] 0 | 0 | 0 |
| **PROJECT D** | | | | | | |
| 7–O | 0 | 10 | 5 | 0 | 0 | 0 |
| 5–2H | 55 | 65 | 55 | 30 | 30 | 25 |

[1] Figures indicate the number of sacks of portland and natural cement in a 7-sack batch; letters refer to the brand of natural cement.
[2] Rating of 100 indicates all 8 specimens sound; rating of 0 indicates all 8 specimens disintegrated.
[3] At 65 alternations.
[4] At 60 alternations.

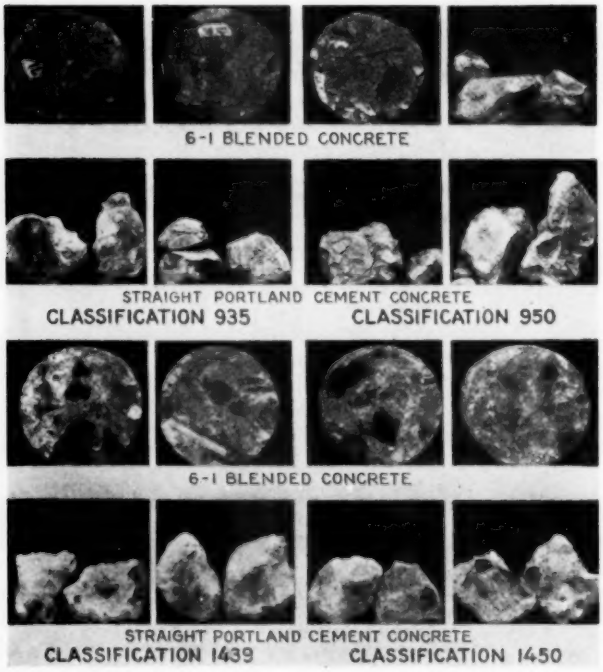


FIGURE 12.—PROJECT A. APPEARANCE OF BLENDED AND STRAIGHT PORTLAND CEMENT CONCRETE SPECIMENS AFTER 35 ALTERNATIONS OF FREEZING AND THAWING IN A 10 PERCENT SOLUTION OF CALCIUM CHLORIDE.

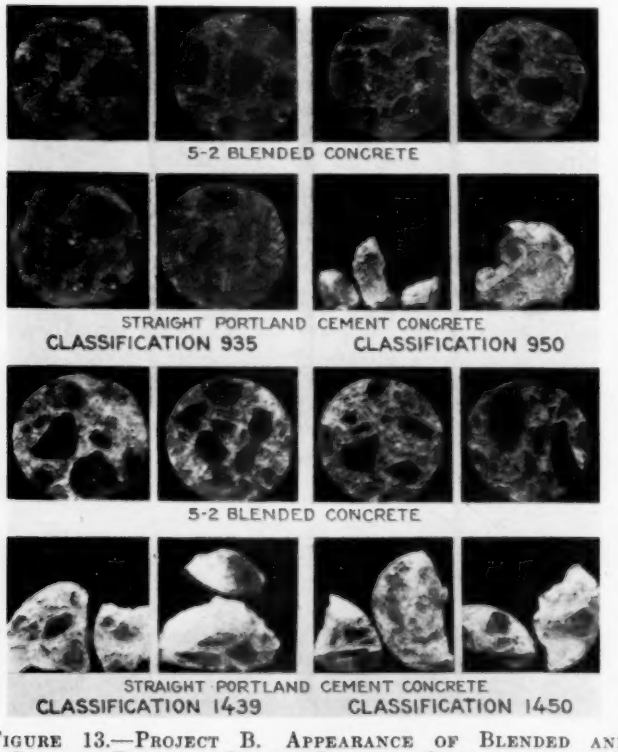


FIGURE 13.—PROJECT B. APPEARANCE OF BLENDED AND STRAIGHT PORTLAND CEMENT CONCRETE SPECIMENS AFTER 35 ALTERNATIONS OF FREEZING AND THAWING IN A 10 PERCENT SOLUTION OF CALCIUM CHLORIDE.

chloride and at the end of 50 alternations in water is shown in figures 12 to 19 inclusive. In each of these figures the specimens are arranged as follows: The four specimens shown in the upper left quadrant contain

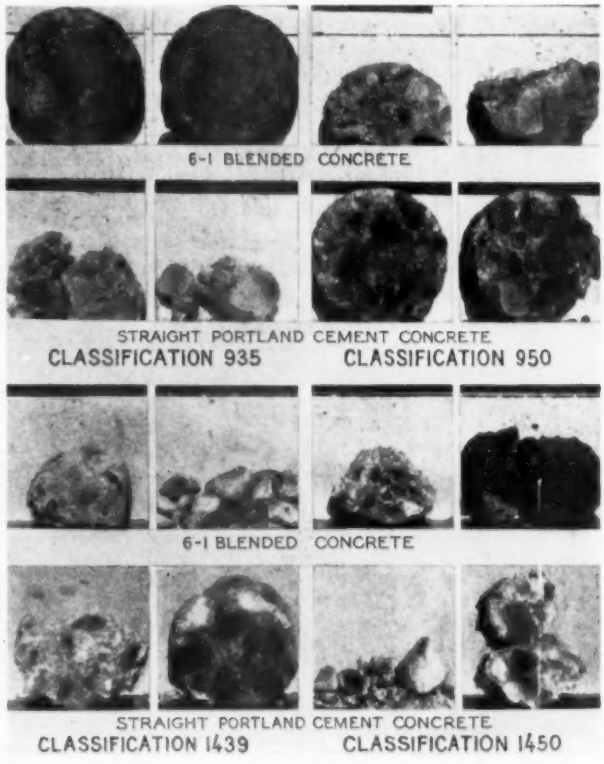


FIGURE 14.—PROJECT C. APPEARANCE OF BLENDED AND STRAIGHT PORTLAND CEMENT CONCRETE SPECIMENS AFTER 35 ALTERNATIONS OF FREEZING AND THAWING IN A 10 PERCENT SOLUTION OF CALCIUM CHLORIDE.

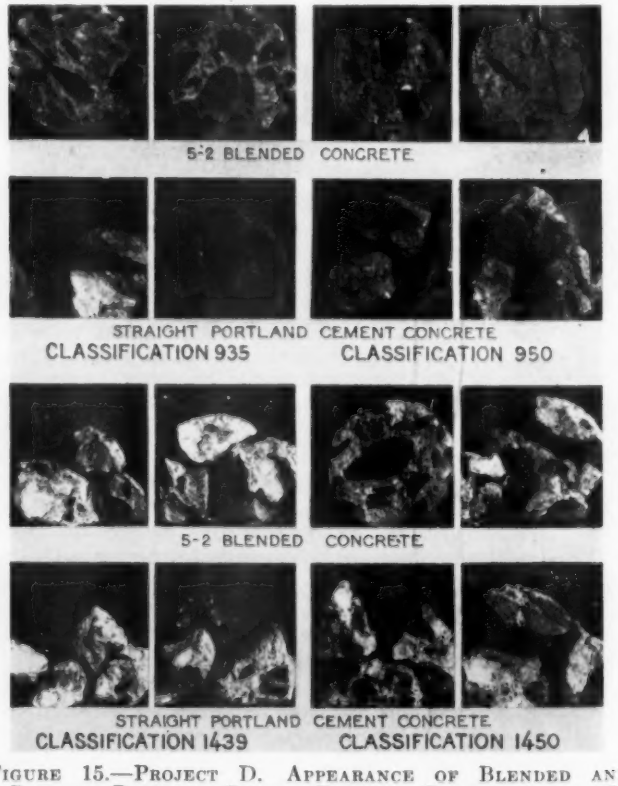


FIGURE 15.—PROJECT D. APPEARANCE OF BLENDED AND STRAIGHT PORTLAND CEMENT CONCRETE SPECIMENS AFTER 35 ALTERNATIONS OF FREEZING AND THAWING IN A 10 PERCENT SOLUTION OF CALCIUM CHLORIDE.

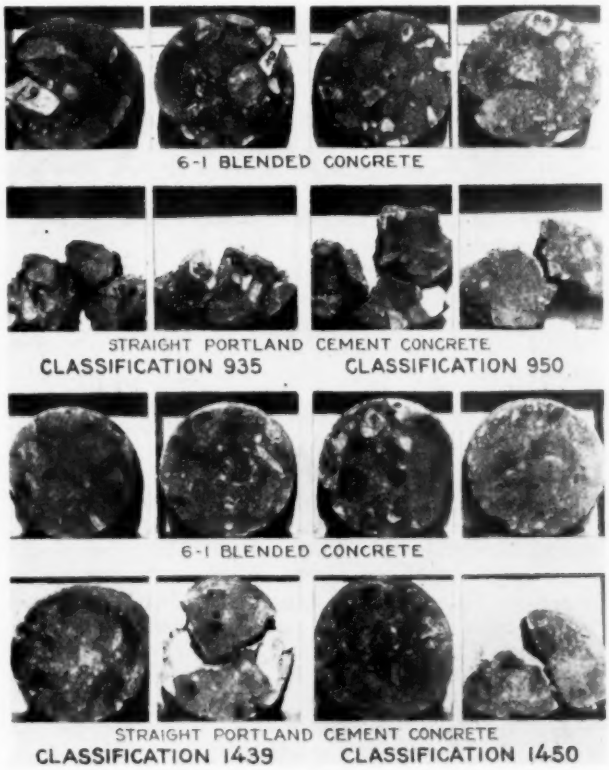


FIGURE 16.—PROJECT A. APPEARANCE OF BLENDED AND STRAIGHT PORTLAND CEMENT CONCRETE SPECIMENS AFTER 50 ALTERNATIONS OF FREEZING AND THAWING IN WATER.

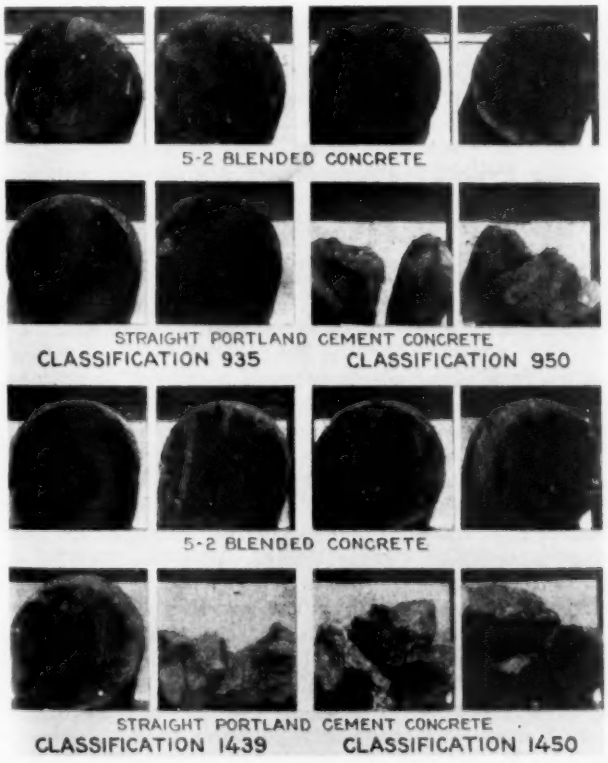


FIGURE 17.—PROJECT B. APPEARANCE OF BLENDED AND STRAIGHT PORTLAND CEMENT CONCRETE SPECIMENS AFTER 50 ALTERNATIONS OF FREEZING AND THAWING IN WATER.

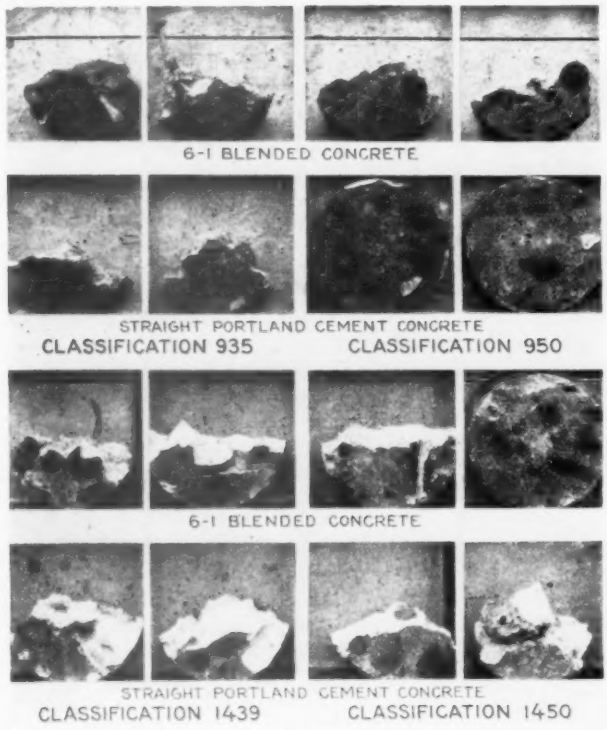


FIGURE 18.—PROJECT C. APPEARANCE OF BLENDED AND STRAIGHT PORTLAND CEMENT CONCRETE SPECIMENS AFTER 50 ALTERNATIONS OF FREEZING AND THAWING IN WATER.

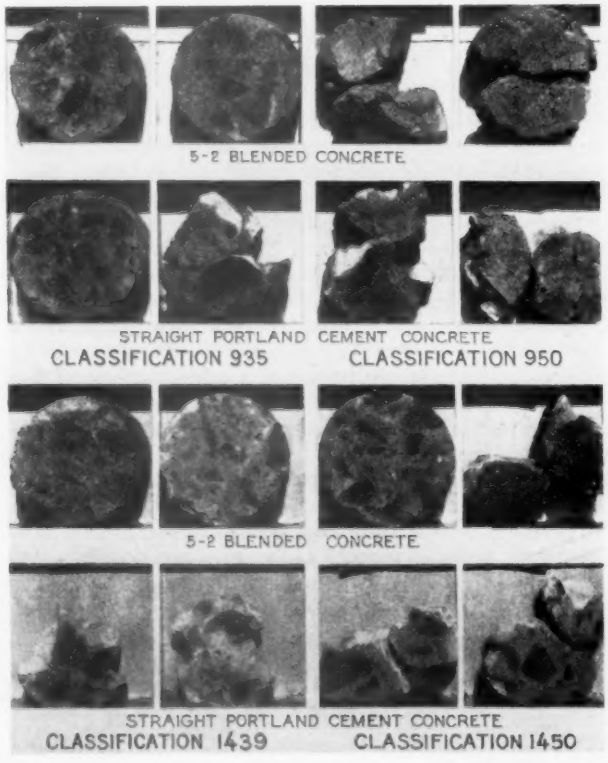


FIGURE 19.—PROJECT D. APPEARANCE OF BLENDED AND STRAIGHT PORTLAND CEMENT CONCRETE SPECIMENS AFTER 50 ALTERNATIONS OF FREEZING AND THAWING IN WATER.

portland cement conforming to New York State specification classification 935, the two specimens in the top row containing the blended cement and the two specimens in the second row the straight portland cement. Similarly, the four specimens in the upper right quadrant contain cement conforming to the 950 classification, those in the lower left quadrant the 1439 cement, and those in the lower right quadrant the 1450 cement.

Referring to table 12 and to figures 12 to 15, inclusive, it will be noted that the use of the blend resulted in a marked increase in resistance to freezing in calcium chloride in Projects A and B, some improvement in Project D and no improvement in Project C. Projects A and B contained natural cement G in the blend, whereas natural cement H was used in Projects C and D.

A study of the individual results shows that in Project A all eight of the straight portland cement specimens disintegrated, while seven of the blended cement specimens remained sound. In Project B, six of the eight straight portland cement specimens disintegrated, whereas all eight of the blended specimens remained sound. In Project C five of the unblended specimens disintegrated as compared to six of the specimens containing the blended cement. In Project D all eight of the unblended specimens disintegrated, whereas three of the blended specimens disintegrated and one was unsound.

The comparative effect of freezing in calcium chloride and in water may be noted by comparing the ratings at 35 alternations as shown in the second and third columns of table 12. It will be observed that in Projects A and B the action in water was less severe than in calcium chloride. However, in Projects C and D the amount of disintegration was about the same for freezing in both liquids. The comparatively low resistance of Projects C and D to freezing in water would indicate that the quality of the concrete was inferior to that in Projects A and B.

Study of the comparative behavior of the various specimens when frozen in water for periods beyond 35 cycles may also be made by referring to table 12. In Projects A and B, virtually the same resistance is shown for the blended cements when frozen in water up to 150 cycles as was indicated when the specimens were frozen in calcium chloride for 35 cycles. However, it will be observed that the straight portland cement concrete in Project B was considerably more resistant to freezing and thawing in water at periods beyond 35 cycles than was the concrete in Project A. The concrete in Project C appeared to be definitely inferior, all specimens in both the straight portland and the blend having disintegrated at either 60 or 65 cycles. In Project D the behavior of the straight portland cement concrete specimens also indicated comparatively inferior concrete as compared to Projects A and B. However, the blended specimens from Project D were considerably more resistant than those containing straight portland cement although, as indicated above, the improvement was not as marked as in Projects A and B.

#### BLENDING FOUND TO INCREASE DURABILITY BY REDUCING BLEEDING

The comparative resistance of the individual specimens when frozen in water may be studied by referring to figure 20, which shows for each test disk the number of cycles at which the various stages of unsoundness were observed. Thus, for Project A, cement classification 1439, the figure shows that of the two unblended cement specimens, one developed questionable soundness at 50 alternations, became definitely unsound at 60, and disintegrated at 75. The other specimen was questionable at 20 alternations and disintegrated at 25. The two blended specimens were sound at 150 alternations. It will be observed that there is no consistent relation between composition of cement and resistance to freezing. This has already been commented upon and would appear to justify the method of rating the groups as a whole as shown in table 12.

An interesting feature of figure 20 is the close agreement which was observed in general between the behavior of the two specimens representing a given concrete. In many cases, failure progressed at almost an identical rate. The figure also shows the comparatively low resistance offered by the blended cement specimens from Projects C and D. Whether this was caused by the fact that natural cement H was used or by the fact that the concrete in these projects appeared, in general, to be of poorer quality than the concrete used in Projects A and B was not determined definitely. The fact remains, however, that the use of natural cement H did not improve the concrete in Project C at all and that while some improvement was shown for Project D, the results were not so positive as those indicated for Projects A and B, in both of which natural cement G was used.

Although there will be no extended discussion of the action of the blended cement concrete as compared to concrete containing only portland cement, there were certain physical differences noted in the concrete at the time the specimens were fabricated which will be discussed briefly. It has been observed in the field that there is less bleeding or water gain in concrete made with the blended cement than there is when portland cement is used alone. This observation led to a short laboratory investigation, the purpose of which was to determine the amount of water accumulating on the top of the fabricated specimens.

The concrete was proportioned in accordance with New York State highway specifications and contained approximately 6.3 sacks of cement per cubic yard. A slump of 2½ inches was used, requiring a water-cement ratio of 0.70.

Test specimens consisted of 6- by 6- by 21-inch beams molded in the usual way. After molding, the tops of the specimens were exposed to the laboratory air. Two specimens were made using 100 percent portland cement, two using a blend of 86 percent portland cement and 14 percent natural cement, and two using 72 percent portland cement and 28 percent natural cement.

At stated intervals after molding, the water which had accumulated at the top was carefully removed. The total water removed at the end of 2½ hours is shown in table 13, expressed as a percentage of the free water going into the concrete. This table also gives the results of a second test made several days later, showing the total water removed at the end of 4 hours.

From the results shown in the table it is evident that the substitution of natural cement for portland cement was effective in reducing bleeding. As will be noted, the bleeding was reduced as the amount of natural cement was increased, a replacement of 28 percent resulting in a reduction of more than one-half. Assuming that bleeding leaves the upper layer of concrete porous and weak as compared to the lower structure, it is apparent that the use of materials or methods of manipulation which will reduce bleeding should prove beneficial.

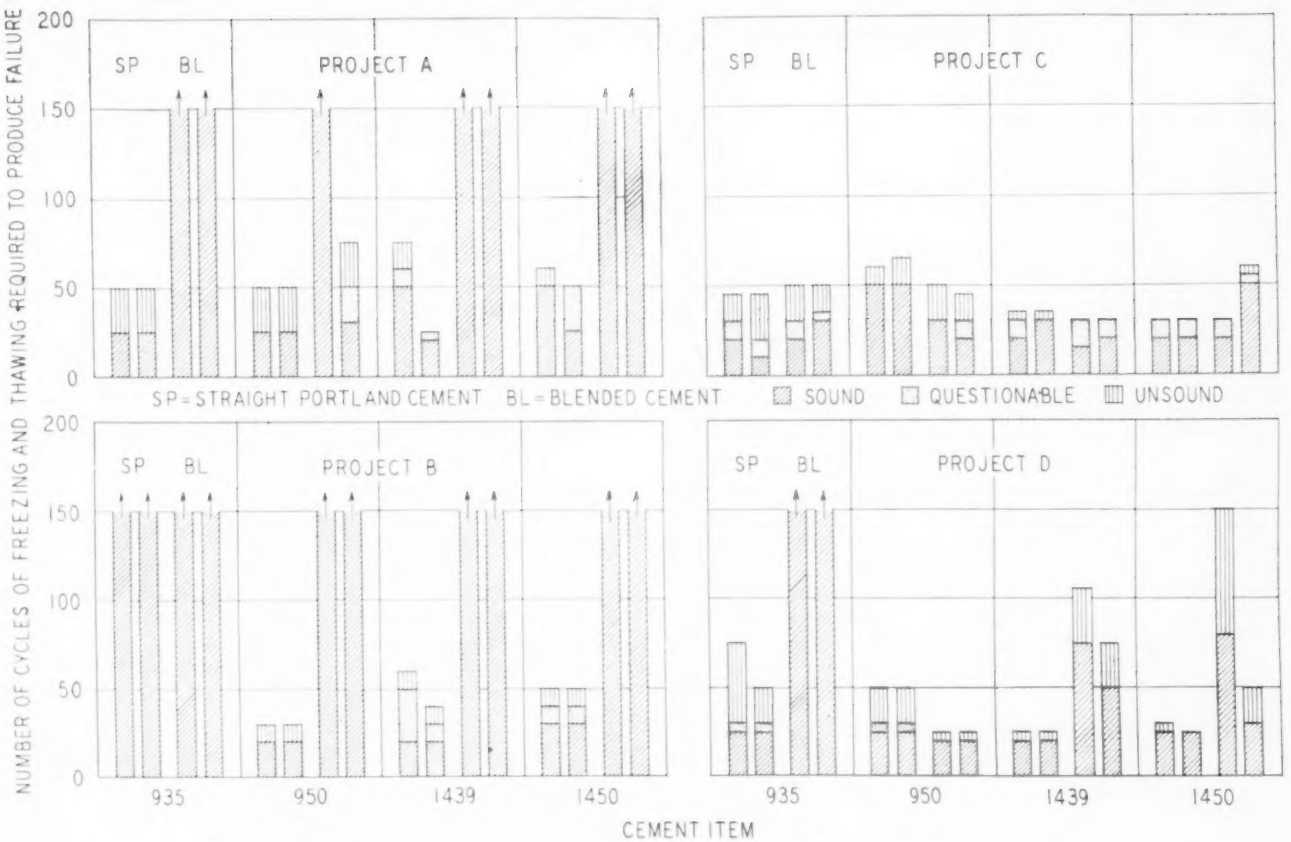


FIGURE 20.—EFFECT OF FREEZING AND THAWING CONCRETE CORE SPECIMENS IN WATER.

TABLE 13.—*Water removed from tops of 6 by 6 by 21-inch beam specimens in bleeding tests*

| Cement blend | | Water removed from specimens [1] | |
|---|---|---|---|
| Portland | Natural cement G | First test | Second test |
| | *Percent* | *Percent* | *Percent* |
| 100 percent | 0 | 7.6 | 7.4 |
| 86 percent | 14 | 4.6 | 4.8 |
| 72 percent | 28 | 3.5 | 2.9 |

[1] Based on total free water in concrete.

Data have been presented to show how the substitution of natural cement for portland cement materially increased the resistance to frost action of the top portions of the drilled cores.

In order to determine what effect water travel or bleeding has on durability, 2-inch disks were cut from the tops and also the bottoms of 9 identical cores and alternately frozen and thawed in a 10-percent calcium chloride solution until failure occurred. It was found that the average number of alternations required to produce failure was 20 for the tops of the cores and 35 for the bottoms, a difference of 15 alternations. All of the specimens were taken from Projects A and B and represented five different portland cements, none of which was blended with natural cement.

### SUMMARY OF RESULTS

In the summary given below reference to a 1- or 2-sack replacement of portland cement by natural cement corresponds to a 14 or 28 percent replacement by weight, respectively. The values for strength are the averages of results of tests at all ages at which determinations were made.

A. The results of tests on specimens fabricated in the laboratory indicate that replacing a portion of the portland cement with natural cement:

1. Reduced the average crushing strength of 1:2 mortar specimens 7 percent for the 1-sack replacement and 19 percent for the 2-sack replacement (figs. 2 and 3).

2. Reduced the average flexural strength of 1:2 mortar specimens 6 percent for the 1-sack replacement and 15 percent for the 2-sack replacement (figs. 4 and 5).

3. Increased expansion of 1:2 mortar bars under continuous water storage up to 180 days (figs. 6 and 7).

4. Slightly increased contraction of 1:2 mortar bars under air storage conditions up to 120 days (figs. 6 and 7).

5. Considerably reduced the expansion of 1:2 mortar bars caused by repeated freezing and thawing, followed by heating, cooling and resaturation (figs. 8 and 9).

6. Decreased the bulk specific gravity and increased the water absorption of 1:2 mortar specimens (table 9).

7. Reduced the expansion of 1:5 mortar bars when subjected to the action of a 10-percent sulphate solution (fig. 10).

8. Increased the expansion of neat cement bars when subjected to the autoclave test at 420° F. for 3 hours (fig. 10).

9. Reduced the average crushing strength of concrete specimens containing 6 sacks of cement per cubic yard of concrete, 4 percent for the 1-sack replacement and 12 percent for the 2-sack replacement (fig. 11).

10. Increased the average flexural strength of concrete specimens containing 6 sacks of cement per cubic yard of concrete 1 percent for the 1-sack replacement and reduced the flexural strength 6 percent for the 2-sack replacement (fig. 11).

11. Decreased the average modulus of elasticity of concrete specimens containing 6 sacks of cement per cubic yard of concrete 1 percent for the 1-sack replacement and 5 percent for the 2-sack replacement (fig. 11).

B. The results of tests on cores taken from concrete pavements indicate that replacing a portion of the portland cement with natural cement considerably increased the resistance of the surface of the concrete to freezing and thawing in water and in a 10-percent solution of calcium chloride (table 12 and fig. 20).

In the tests covered by the above statement greater improvement in resistance was obtained by the use of natural cement G than by the use of natural cement H.

#### CONCLUSIONS

These tests indicate that, although the crushing and flexural strength of pavement concrete may be slightly reduced by the replacement of 14 or 28 percent of the portland cement with natural cement G, the resistance of the pavement surface to alternate freezing and thawing will be materially increased. No laboratory tests were made using natural cement H and tests of field specimens indicate that natural cement H did not improve the resistance of the concrete to the same extent as natural cement G.

## HIGHWAY RESEARCH BOARD TO MEET SOON

The Eighteenth Annual Meeting of the Highway Research Board of the National Research Council will be held in Washington, D. C., Monday, November 28, to Friday, December 2, 1938. Reports on highway research investigations will be presented, and the formal meetings of the Board will be interspersed with open meetings for informal discussion of pertinent topics. A program of reports is to be announced by the Board in the near future.

DISPOSITION OF STATE MOTOR-FUEL TAX RECEIPTS, 1937

# DISPOSITION OF STATE MOTOR-FUEL TAX RECEIPTS, 1937

[Compiled for calendar year from reports of State authorities]

| State | Net total receipts of calendar year | Adjustments to undistributed funds etc. [1] | Tax on aviation gasoline deducted | Net total funds distributed [2] | Expenses of collection and administration | For other administrative purposes [3] | For State highway purposes: Construction, maintenance, and administration [4] | For State highway purposes: State highway police | For State highway purposes: Service of State highway obligations: State highway bonds and notes | For State highway purposes: Service of State highway obligations: State assumed local obligations [5] | For State highway purposes: Service of State highway obligations: Total | For State highway purposes: Total for State highway purposes | For local roads and streets [6]: For work on county and local roads [6] | For local roads and streets [6]: For work on city streets [7] | For local roads and streets [6]: Service of local highway obligations | For local roads and streets [6]: Total | For other highway purposes (park and forest roads, etc.) | For nonhighway purposes: To general funds [8]: Inspection fees, dealers licenses, etc. | For nonhighway purposes: To general funds [8]: Motor-fuel tax | For nonhighway purposes: For relief of unemployment or destitution | For nonhighway purposes: For education | For nonhighway purposes: For other specific purposes [9] | For nonhighway purposes: Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* |
| Alabama | 13,350 | 61 | | 13,411 | 82 | 56 | 4,195 | | 2,392 | | 2,392 | 6,587 | 6,686 | | | 6,686 | | | | | | | |
| Arizona | 4,333 | | | 4,333 | 96 | | 2,829 | 104 | | | | 2,933 | [*]1,297 | | | 1,297 | | | | | | 7 | 7 |
| Arkansas | 9,962 | | | 9,962 | 348 | 3 | 2,251 | | 4,440 | 2,111 | 6,551 | 8,802 | 623 | | 104 | 727 | | 82 | | | | | 82 |
| California | 46,624 | −1,205 | | 45,419 | 168 | | 26,373 | | | | | 26,373 | [*]15,283 | 3,595 | | 18,878 | | | | | | | |
| Colorado | 7,431 | −30 | | 7,401 | 89 | 23 | 4,528 | 236 | 570 | | 570 | 5,334 | 1,955 | | | 1,955 | | | | | | | |
| Connecticut | 9,496 | −209 | | 9,287 | 51 | | 7,406 | | | 1,830 | 1,830 | 9,236 | | | | | | | | | | | |
| Delaware | 2,034 | | | 2,034 | 11 | | [4] 1,364 | 133 | 41 | 329 | 370 | 1,867 | [*] | 13 | | 13 | 138 | | | | 5 | 5 | |
| Florida | 22,466 | 16 | | 22,482 | 24 | 395 | 9,123 | 39 | | 3,300 | 3,300 | 12,462 | 103 | 38 | 6,293 | 6,434 | | | 2,542 | | 604 | 21 | 3,167 |
| Georgia | 19,550 | | | 19,550 | 600 | | 10,170 | | | 2,399 | 2,399 | 12,569 | 3,142 | | | 3,142 | | | | | 3,239 | | 3,239 |
| Idaho | 4,037 | 43 | 6 | 4,074 | 15 | | 4,056 | 3 | | | | 4,059 | | | | | | | | | | | |
| Illinois | 36,266 | 42 | | 36,308 | 353 | 261 | 11,836 | | | | | 11,836 | [*]8,412 | [*]7,970 | | 16,382 | | 168 | | 4,409 | 2,899 | | 7,476 |
| Indiana | 23,497 | 2,957 | | 26,454 | 91 | 92 | 14,355 | | | | | 14,355 | 9,208 | 2,290 | | 11,498 | | 418 | | | | | 418 |
| Iowa | 13,047 | 55 | | 13,102 | 81 | 23 | 3,921 | | | 3,269 | 3,269 | 7,190 | [*]5,808 | | | 5,808 | | | | | | | |
| Kansas | 10,236 | 4 | | 10,240 | 337 | 106 | 6,317 | 72 | 238 | 689 | 927 | 7,316 | 2,481 | | | 2,481 | | | | | | | |
| Kentucky | 12,671 | 46 | | 12,717 | 48 | | 12,461 | 153 | | | | 12,614 | 55 | | | 55 | | | | | | | |
| Louisiana | 16,000 | −3 | | 15,997 | 87 | 74 | 1,100 | 87 | 7,521 | | 7,521 | 8,708 | | 262 | | 262 | | | | 4,622 | 1,122 | 1,122 | 6,866 |
| Maine | 5,550 | | | 5,550 | 19 | | 3,364 | 165 | 1,443 | | 1,443 | 4,972 | 559 | | | 559 | | | | | | | |
| Maryland | 9,857 | 13 | | 9,870 | 34 | | 3,929 | | [10] 1,456 | | 1,456 | 5,385 | 930 | 2,786 | 735 | 4,451 | | | | | | | |
| Massachusetts | 19,836 | | | 19,836 | 50 | | 5,145 | 247 | [11] 2,292 | | 2,292 | 7,684 | 2,933 | | [11] 345 | 3,278 | [11] 833 | | 6,600 | [11] 1,391 | | | 7,991 |
| Michigan | 29,430 | 127 | 50 | 29,507 | 253 | | 19,699 | | 3,000 | | 3,000 | 22,699 | [*]6,550 | | | 6,550 | | 5 | | | | | 5 |
| Minnesota | 15,493 | | | 15,493 | 49 | 100 | 10,051 | 144 | | | | 10,195 | [*]5,098 | | | 5,098 | | 51 | | | | | 51 |
| Mississippi | 10,222 | 7 | | 10,229 | 91 | | 2,818 | 38 | 2,562 | | 2,562 | 5,418 | [*]4,267 | | | 4,267 | 453 | | | | | | |
| Missouri | 11,217 | | | 11,217 | 55 | 51 | 6,913 | 205 | 3,919 | | 3,919 | 11,037 | | | | | | 74 | | | | | 74 |
| Montana | 4,581 | 68 | | 4,649 | 19 | | 4,064 | | 566 | | 566 | 4,630 | | | | | | | | | | | |
| Nebraska | 11,030 | | 25 | 11,005 | 105 | | 6,327 | | | | | 6,327 | [*]3,020 | 331 | | 3,351 | | | | 1,222 | | | 1,222 |
| Nevada | 1,177 | | | 1,177 | 4 | | 1,135 | 29 | | 9 | 9 | 1,173 | | | | | | | | | | | |
| New Hampshire | 3,286 | 1 | | 3,287 | [12] | | 2,012 | 40 | 825 | | 825 | 2,877 | 245 | | [13] 152 | 397 | 13 | | | | | | |
| New Jersey | 21,593 | 193 | | 21,786 | 148 | | 1,614 | | 7,633 | | 7,633 | 9,247 | 3,443 | | 557 | 4,000 | 68 | | | 6,322 | 1,238 | 763 | 8,323 |
| New Mexico | 4,022 | −25 | | 3,997 | 90 | 2 | 2,302 | | 1,603 | | 1,603 | 3,905 | | | | | | | | | | | |
| New York [14] | 61,915 | −4,408 | | 57,507 | 97 | | 8,808 | 488 | 3,715 | | 3,715 | 13,011 | [*]8,545 | 1,680 | | 10,225 | 2,081 | | 32,093 | | | | 32,093 |
| North Carolina | 23,393 | −26 | | 23,367 | [15] | 55 | [4]14,216 | 449 | 6,907 | 346 | 7,253 | 21,918 | [*] | | | | | 877 | 500 | | | 17 | 1,394 |
| North Dakota | 2,935 | −133 | | 2,802 | 12 | 61 | 1,621 | | 189 | | 189 | 1,810 | 905 | | | 905 | | | 14 | | | | 14 |
| Ohio | [16]46,538 | 485 | | 47,023 | 156 | | 19,329 | | | | | 19,329 | 8,707 | 6,814 | | 15,521 | | | | | 12,017 | | 12,017 |
| Oklahoma | 13,772 | −298 | | 13,474 | 359 | | 7,905 | | | | | 7,905 | [*]3,352 | | | 3,352 | | 4 | | | | 1,854 | 1,858 |
| Oregon | 9,801 | 25 | 8 | 9,818 | 37 | | 5,258 | 236 | 2,733 | | 2,733 | 8,227 | [*]1,467 | | | 1,467 | 33 | | 54 | | | | 54 |
| Pennsylvania | 55,720 | [17] 8,100 | | 63,820 | 298 | | 37,889 | 1,246 | 2,973 | | 2,973 | 42,108 | [*]7,032 | 238 | | 7,270 | 52 | | | 13,854 | | 238 | 14,092 |
| Rhode Island [14] | 3,094 | 24 | | 3,118 | 22 | | 1,548 | 79 | 150 | | 150 | 1,777 | 229 | | | 229 | 16 | | 1,074 | | | | 1,074 |
| South Carolina | 11,135 | 9 | 31 | 11,113 | [18] 39 | [18] 11 | 4,620 | | 1,523 | 2,924 | 4,447 | 9,067 | [*]1,812 | | | 1,812 | | 184 | | | | | 184 |
| South Dakota | 4,155 | 343 | 3 | 4,495 | 49 | 46 | 2,661 | 3 | | | | 2,664 | | | | | 36 | 38 | | | | 1,662 | 1,700 |
| Tennessee | 18,938 | −676 | 39 | 18,223 | 179 | 93 | 2,458 | | 6,815 | 1,211 | 8,026 | 10,484 | 5,041 | | | 5,041 | | 981 | | | | 1,445 | 2,426 |
| Texas | 41,678 | −52 | | 41,626 | 642 | | 20,492 | | | 10,246 | 10,246 | 30,738 | | | | | | | | | 10,246 | | 10,246 |
| Utah | 3,424 | 69 | 36 | 3,457 | 12 | | 3,312 | 133 | | | | 3,445 | | | | | | | | | | | |
| Vermont | 2,323 | 183 | | 2,506 | 3 | | 1,291 | | 310 | | 310 | 1,601 | | | 897 | 897 | 5 | | | | | | |
| Virginia | 16,122 | 37 | | 16,159 | [18] | 47 | [4]15,318 | | 518 | | 518 | 15,836 | [4] 267 | | | 267 | | | | | | 9 | 9 |
| Washington | 15,282 | | | 15,282 | 26 | | 5,951 | | [11] 119 | 52 | 171 | 6,122 | [*]6,482 | 1,550 | [11] 97 | 8,129 | | | | [11] 1,005 | | | 1,005 |
| West Virginia | 8,496 | | | 8,496 | 11 | | [4] 4,066 | | 4,419 | | 4,419 | 8,485 | [*] | | | | | | | | | | |
| Wisconsin | 19,751 | 400 | | 20,151 | 72 | 214 | 9,717 | | | 2,584 | 2,584 | 12,301 | 4,419 | 699 | | 5,118 | 142 | | 2,304 | | | | 2,304 |
| Wyoming | 2,500 | | 33 | 2,467 | 13 | | 1,679 | 47 | 112 | | 112 | 1,838 | 616 | | | 616 | | | | | | | |
| District of Columbia | 2,732 | | | 2,732 | [19] | | | | | | | | | 2,724 | | 2,724 | | 8 | | | | | 8 |
| Total | 761,998 | 6,243 | 231 | 768,010 | 5,425 | 1,713 | 359,797 | 4,376 | 70,984 | 31,299 | 102,283 | 466,456 | 130,972 | 30,990 | 9,180 | 171,142 | 3,870 | 2,890 | 45,181 | 32,825 | 31,365 | 7,143 | 119,404 |

[1] Amounts distributed during the calendar year often differ from actual collections because of undistributed funds and lag between accounts of collecting and expending agencies.

[2] In many States the proceeds of highway user taxes are placed in a common fund from which a distribution is made. The amounts so distributed have been prorated in proportion to the receipts not otherwise dedicated. See the following tables.

[3] Where reported separately from collection expenses, funds allotted for motor-fuel inspection, administration of motor vehicle department, and regulation of motor vehicles are shown in this column.

[4] The following allotments for construction and maintenance of county roads under State control are included in State highway purposes: Delaware, $259,000; North Carolina, $7,499,000; Virginia, $7,000,000; West Virginia, $1,231,000.

[5] Reimbursement to local units of Government for amounts spent on roads now on State system.

[6] In States indicated by star (*) law provides that these funds may also be used for service of local highway obligations. Amounts so used not reported separately. In Colorado funds may be used on both State and local roads.

[7] This column shows specific allotments for city streets. Where reported separately, funds alloted for urban extensions of State highway system are included in allotments for State highway purposes.

[8] To State general funds except in Wisconsin, where amount went to towns, cities, and villages in lieu of personal property taxes formerly imposed on motor vehicles. Allocations to local general funds may have been used in part for highways, but such amounts not reported.

[9] For the following purposes: Arizona, irrigation engineering expenses; Delaware, beach protection; Florida, aviation; Louisiana, harbor improvement; New Jersey, service of institutional construction bonds, $520,000, and Department of Commerce and Aviation, $243,000; North Carolina, State probation commission; Oklahoma, service of general State debt; Pennsylvania, aircraft landing fields, $214,000, and cooperative work other departments, $24,000; South Dakota, payment on real estate bonds; Tennessee, debt service on nonhighway bonds; Virginia, aviation.

[10] Legislative restorations from proceeds of sale of general State bonds were applied to debt service payments, thus reducing amounts necessary from current revenue.

[11] Includes debt service charges on emergency relief bond issues prorated in proportion to use of proceeds for State highway, local road, other highway, and nonhighway purposes.

[12] Paid out of motor-vehicle revenue, $3,000. See the following table.

[13] Service of highway relief bonds, a State obligation incurred for improvement of local roads.

[14] Appropriations for highway purposes out of State general fund have been credited against payments of motor-fuel tax and motor-vehicle fees to the general fund and prorated in proportion to net receipts not otherwise dedicated.

[15] Included in cost of collecting motor-vehicle revenue. See the following table.

[16] Tax of $662,000 on non-motor-vehicle fuels not included.

[17] Amounts previously loaned to general fund for relief purposes entirely repaid during 1937.

[18] Estimated from fiscal-year appropriations.

[19] Paid out of general revenue. Amount not reported.

# DISPOSITION OF STATE MOTOR-VEHICLE RECEIPTS, 1937

[Compiled for calendar year from reports of State authorities]

| State | Net total receipts of calendar year | Adjustments due to undistributed funds, etc.[1] | Net total funds distributed [2] | Expenses of collection and administration [3] | For other administrative purposes [4] | For State highway purposes: Construction, maintenance, and administration [5] | For State highway purposes: State highway police | For State highway purposes: Service of State highway obligations: State highway bonds and notes | For State highway purposes: Service of State highway obligations: State-assumed local obligations [6] | For State highway purposes: Service of State highway obligations: Total | For State highway purposes: Total for State highway purposes | For local roads and streets [7]: For work on county and local roads [8] | For local roads and streets [7]: For work on city streets [8] | For local roads and streets [7]: Service of local highway obligations | For local roads and streets [7]: Total | For other highway purposes (park and forest roads, etc.) | For nonhighway purposes: To general funds [9] | For nonhighway purposes: For relief of unemployment or destitution | For nonhighway purposes: For education | For nonhighway purposes: For other specific purposes [10] | For nonhighway purposes: Total | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* |
| Alabama | 4,439 | 135 | 4,574 | 484 | | 2,085 | 406 | 835 | | 835 | 3,326 | | | | | | 764 | | | | 764 | 764 |
| Arizona | 1,143 | | 1,143 | 235 | | 876 | 32 | | | | 908 | | | | | | | | | | | |
| Arkansas | 3,241 | | 3,241 | 101 | | 770 | 130 | 1,518 | 722 | 2,240 | 3,140 | | | | | | | | | | | |
| California | 24,003 | 1,069 | 25,072 | 3,028 | 145 | 3,744 | 2,641 | 3,964 | | 3,964 | 10,349 | *3,794 | | | 3,794 | | 7,756 | | | | 7,756 | 7,756 |
| Colorado | 2,603 | 5 | 2,608 | 466 | 55 | 898 | 49 | 119 | | 119 | 1,066 | 1,021 | | | 1,021 | | | | | | | |
| Connecticut | 6,691 | −407 | 6,284 | 1,124 | | 1,501 | 325 | | 371 | 371 | 2,197 | 2,963 | | | 2,963 | | | | | | | |
| Delaware | 1,202 | 75 | 1,277 | 104 | | [5] 790 | 77 | 24 | 191 | 215 | 1,082 | (11) | 8 | | 8 | 80 | | | | 3 | 3 | 3 |
| Florida | 6,196 | | 6,196 | 464 | 224 | | | | | | | | | | | | | | 5,508 | | 5,508 | 5,508 |
| Georgia | 2,368 | | 2,368 | 264 | | 941 | 320 | | 222 | 222 | 1,483 | 621 | | | 621 | | | | | | | |
| Idaho | 2,498 | −25 | 2,473 | 71 | | 289 | 101 | | | | 390 | *2,012 | | | 2,012 | | | | | | | |
| Illinois | 21,430 | 422 | 21,852 | 831 | 361 | 8,907 | 1,436 | 8,837 | 382 | 9,219 | 19,562 | 891 | | | 891 | | 207 | | | | 207 | 207 |
| Indiana | 9,827 | 29 | 9,856 | 931 | | 3,907 | 446 | | | | 4,353 | 1,561 | 390 | | 1,951 | | 2,621 | | | | 2,621 | 2,621 |
| Iowa | 11,918 | 67 | 11,985 | 1,387 | | 5,780 | | | 4,818 | 4,818 | 10,598 | | | | | | | | | | | |
| Kansas | 4,537 | −260 | 4,277 | 709 | | 2,301 | 26 | 86 | 251 | 337 | 2,664 | 904 | | | 904 | | | | | | | |
| Kentucky | 5,125 | −4 | 5,121 | 469 | 26 | 2,174 | 27 | | | | 2,201 | 600 | | | 600 | | 1,825 | | | | 1,825 | 1,825 |
| Louisiana | 4,710 | −201 | 4,509 | 73 | | 2,946 | 325 | 447 | | 447 | 3,718 | | 718 | | 718 | | | | | | | |
| Maine | 3,865 | −1 | 3,864 | 151 | | 2,259 | 110 | 969 | | 969 | 3,338 | 375 | | | 375 | | | | | | | |
| Maryland | 5,577 | −1,006 | 4,571 | 522 | 56 | 1,694 | 378 | [11] 1,107 | | 1,107 | 3,179 | | 814 | | 814 | | | | | | | |
| Massachusetts | 6,875 | 213 | 7,088 | 1,580 | 35 | 2,136 | 103 | [12] 951 | | 951 | 3,191 | 1,217 | | [12] 143 | 1,360 | [12] 346 | | [12] 577 | | | 577 | 577 |
| Michigan | 22,085 | −209 | 21,876 | 1,700 | | 455 | 321 | | | | 776 | *19,129 | | | 19,129 | | 271 | | | | 271 | 271 |
| Minnesota | 8,867 | 35 | 8,902 | 428 | | 4,214 | 137 | 1,748 | 2,261 | 4,009 | 8,360 | | | | | | 114 | | | | 114 | 114 |
| Mississippi | 2,248 | −11 | 2,237 | 108 | | 212 | | | | | 212 | *1,917 | | | 1,917 | | | | | | | |
| Missouri | 9,638 | −10 | 9,628 | 615 | | 5,645 | 168 | 3,200 | | 3,200 | 9,013 | | | | | | | | | | | |
| Montana | 1,532 | 95 | 1,627 | 73 | | | 159 | | | | 159 | 1,354 | 41 | | 1,395 | | | | | | | |
| Nebraska | 2,603 | −159 | 2,444 | 201 | 21 | 657 | 75 | | | | 732 | 1,482 | | | 1,482 | | 8 | | | | 8 | 8 |
| Nevada | 282 | | 282 | 25 | | 166 | 4 | 87 | | 87 | 257 | | | | | | | | | | | |
| New Hampshire | 2,347 | 56 | 2,403 | 126 | 3 | 1,770 | 139 | 4 | | 4 | 1,913 | 216 | | [13] 133 | 349 | 12 | | | | | | |
| New Jersey | 19,271 | −23 | 19,248 | 1,767 | | 3,897 | | | | | 3,897 | 5,794 | | 1,345 | 7,139 | 164 | | 6,281 | | | 6,281 | 6,281 |
| New Mexico | 1,544 | 176 | 1,720 | 93 | 114 | 599 | 114 | | | | 713 | 218 | | | 218 | | 582 | | | | 582 | 582 |
| New York [14] | 52,901 | −288 | 52,613 | 2,736 | 176 | 15,279 | 847 | 6,445 | | 6,445 | 22,571 | *10,692 | 4,949 | | 15,641 | 3,609 | 7,880 | | | | 7,880 | 7,880 |
| North Carolina | 8,855 | −637 | 8,218 | 446 | | [5] 5,041 | 159 | 2,449 | 123 | 2,572 | 7,772 | (11) | | | | | | | | | | |
| North Dakota | 1,581 | −19 | 1,562 | 130 | 22 | 632 | 121 | 62 | | 62 | 815 | 595 | | | 595 | | | | | | | |
| Ohio | 25,635 | 1,284 | 26,919 | 1,403 | | 6,273 | 501 | | | | 6,774 | *13,836 | 4,532 | | 18,368 | | | | | 374 | 374 | 374 |
| Oklahoma | 5,584 | 8 | 5,592 | 930 | 180 | 1,693 | 294 | | | | 1,897 | *2,585 | | | 2,585 | | | | | | | |
| Oregon | 3,378 | 19 | 3,397 | 460 | | 1,579 | 71 | 821 | | 821 | 2,471 | *440 | | | 440 | 10 | 16 | | | | 16 | 16 |
| Pennsylvania | 38,332 | [15] 10,788 | 49,120 | 1,990 | | 41,882 | 1,377 | 3,287 | | 3,287 | 46,546 | | 262 | | 262 | 58 | | | | 264 | 264 | 264 |
| Rhode Island [14] | 2,790 | 69 | 2,859 | 258 | | 1,300 | 67 | 126 | | 126 | 1,493 | 193 | | | 193 | 13 | 902 | | | | 902 | 902 |
| South Carolina | 1,690 | | 1,690 | 142 | | 645 | 282 | 213 | 408 | 621 | 1,548 | | | | | | | | | | | |
| South Dakota | 1,650 | −2 | 1,648 | 77 | 4 | 322 | | | | | 322 | 1,242 | | | 1,242 | 3 | | | | | | |
| Tennessee | 4,233 | 8 | 4,241 | 261 | | 3,537 | 443 | | | | 3,980 | | | | | | | | | | | |
| Texas | 19,684 | 25 | 19,709 | 993 | 320 | 6,282 | 443 | | | | 6,725 | *11,671 | | | 11,671 | | | | | | | |
| Utah | 1,049 | −241 | 808 | 123 | 12 | | 11 | 592 | | 592 | 603 | | | | | | 70 | | | | 70 | 70 |
| Vermont | 2,410 | 175 | 2,585 | 87 | | 1,239 | 94 | 298 | | 298 | 1,631 | | | 862 | 862 | 5 | | | | | | |
| Virginia | 6,153 | −2 | 6,151 | 595 | | 4,976 | 205 | 375 | | 375 | 5,556 | | | | | | | | | | | |
| Washington | 4,402 | 52 | 4,454 | 347 | | 2,604 | 1,490 | | | | 4,094 | 13 | | | 13 | | | | | | | |
| West Virginia | 6,162 | | 6,162 | 216 | | [5] 2,845 | 10 | 3,091 | | 3,091 | 5,946 | (11) | | | | | | | | | | |
| Wisconsin | 12,984 | −506 | 12,478 | 774 | 32 | 5,707 | | | 1,518 | 1,518 | 7,225 | 2,596 | 410 | | 3,006 | 83 | 1,358 | | | | 1,358 | 1,358 |
| Wyoming | 597 | −4 | 593 | 4 | | 411 | 12 | 166 | | 166 | 589 | | | | | | | | | | | |
| District of Columbia | 878 | −2 | 876 | 86 | 75 | | | | | | | | | | | | 715 | | | | 715 | 715 |
| Total | 399,613 | 10,788 | 410,401 | 30,188 | 1,861 | 163,770 | 14,476 | 41,821 | 11,267 | 53,088 | 231,334 | 89,932 | 12,124 | 2,483 | 104,539 | 4,383 | 25,089 | 6,858 | 5,508 | 641 | 38,096 | |

[1] Amounts distributed during the calendar year often differ from actual collections because of undistributed funds and lag between accounts of collecting and expending agencies.

[2] In many States the proceeds of highway user taxes are placed in a common fund from which a distribution is made. The amounts so distributed have been prorated in proportion to the receipts not otherwise dedicated. See tables that precede and follow this table.

[3] Collection expenses in many States include service charges deducted by county and local collectors.

[4] Where reported separately from collection expenses, funds allotted for collection of motor-fuel tax, payments to auto theft fund, and miscellaneous expenses of motor-vehicle regulation are shown in this column.

[5] The following allotments for construction and maintenance of county roads under State control are included in State highway purposes: Delaware, $150,000; North Carolina, $2,659,000; West Virginia, $863,000.

[6] Reimbursement to local units of government for amounts spent on roads now on State system.

[7] In States indicated by star (*) law provides that these funds may also be used for service of local highway obligations. Amounts so used not reported separately. In Colorado funds may be used on both State and local roads.

[8] This column includes allotments for city streets. Where reported separately, funds allotted for urban extensions of State highway system are included in allotments for State highway purposes.

[9] To State general funds except in the following States: Alabama, county and municipal general funds; California, general funds of counties and cities, $3,821,000; New Mexico, county general funds, $364,000; Wisconsin, towns, cities, and villages in lieu of personal property tax formerly imposed on motor vehicles, $1,353,000. Allocations to local general funds may have been used in part for highways, but such amounts not reported.

[10] For the following purposes: Delaware, beach protection; Ohio, hospitalization of indigent persons injured in motor-vehicle accidents; Pennsylvania, aircraft landing fields, $237,000, and cooperative work other departments, $27,000.

[11] Legislative restorations from proceeds of sale of general State bonds were applied to debt service payments, thus reducing amounts necessary from current revenue.

[12] Includes debt service charges on emergency relief bond issues prorated in proportion to use of proceeds for State highway, local road, other highway, and nonhighway purposes.

[13] Service of highway relief bonds, a State obligation incurred for improvement of local roads.

[14] Appropriations for highway purposes out of State general fund have been credited against payments of motor-fuel tax and motor-vehicle fees to the general fund and prorated in proportion to net receipts not otherwise dedicated.

[15] Amounts previously loaned to general fund for relief purposes entirely repaid during 1937

extensions of State highway system are included in allotments for [illegible]

# DISPOSITION OF STATE MOTOR-CARRIER TAX RECEIPTS, 1937

[Compiled for calendar year from reports of State authorities]

| State | Net total receipts of calendar year | Adjustments due to undistributed funds, etc.[1] | Net total funds distributed [2] | Expenses of collection and administration | For State highway purposes | | | | | | For local roads and streets [3] | | | | For other highway purposes (park and forest roads, etc.) | For nonhighway purposes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Construction, maintenance, and administration [4] | State highway police | Service of State highway obligations | | | Total for State highway purposes | For work on county and local roads [5] | For work on city streets [6] | Service of local highway obligations | Total | | To general funds | For relief of unemployment or destitution | For education | Total |
| | | | | | | | State highway bonds and notes | State-assumed local obligations [7] | Total | | | | | | | | | | |
| | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* |
| Alabama | 216 | 1 | 217 | 58 | 159 | | | | | 159 | | | | | | | | | |
| Arizona | 162 | −2 | 160 | 13 | 142 | 5 | | | | 147 | | | | | | | | | |
| Arkansas | 2 | | 2 | | 2 | | | | | 2 | | | | | | | | | |
| California | 3,048 | −41 | 3,007 | 544 | 46 | | | | | 46 | 16 | | | 16 | | 2,401 | | | 2,401 |
| Colorado | 621 | 21 | 642 | 98 | 238 | 13 | 31 | | 31 | 282 | 262 | | | 262 | | | | | |
| Connecticut | 211 | −15 | 196 | | 88 | | | 22 | 22 | 110 | 86 | | | 86 | | | | | |
| Delaware | (8) | | | | | | | | | | | | | | | | | | |
| Florida | 262 | −4 | 258 | 32 | | | | | | | 10 | | 210 | 220 | | | | 6 | 6 |
| Georgia | 155 | 226 | 381 | 111 | 218 | | | 52 | 52 | 270 | | | | | | | | | |
| Idaho | 106 | 37 | 143 | 30 | 81 | 32 | | | | 113 | | | | | | | | | |
| Illinois | (8) | | | | | | | | | | | | | | | | | | |
| Indiana | 682 | −148 | 534 | 134 | 400 | | | | | 400 | | | | | | | | | |
| Iowa | 537 | | 537 | 135 | | | | | | | *402 | | | 402 | | | | | |
| Kansas | 1,163 | | 1,163 | 281 | 549 | 38 | 20 | 60 | 80 | 667 | 215 | | | 215 | | | | | |
| Kentucky | 394 | 85 | 479 | 57 | 415 | 5 | | | | 420 | 2 | | | 2 | | | | | |
| Louisiana | 3 | | 3 | 3 | | | | | | | | | | | | | | | |
| Maine | 22 | −4 | 18 | 18 | | | | | | | | | | | | | | | |
| Maryland | (8) | | | | | | | | | | | | | | | | | | |
| Massachusetts | 55 | | 55 | 55 | | | | | | | | | | | | | | | |
| Michigan | 403 | −58 | 345 | 197 | 148 | | | | | 148 | | | | | | | | | |
| Minnesota | 23 | | 23 | 23 | | | | | | | | | | | | | | | |
| Mississippi | 158 | | 158 | 4 | | | | | | | *154 | | | 154 | | | | | |
| Missouri | 521 | 411 | 932 | 79 | 497 | 15 | 281 | | 281 | 793 | 60 | | | 60 | | | | | |
| Montana | 46 | −11 | 35 | 35 | | | | | | | | | | | | | | | |
| Nebraska | 27 | | 27 | 27 | | | | | | | | | | | | | | | |
| Nevada | 198 | | 198 | 12 | 181 | 5 | | | | 186 | | | | | | | | | |
| New Hampshire | 4 | | 4 | 4 | | | | | | | | | | | | | | | |
| New Jersey | 91 | −7 | 84 | | 22 | | | | | 22 | 19 | | 7 | 26 | 1 | | 35 | | 35 |
| New Mexico | 153 | −9 | 144 | 34 | 104 | 6 | | | | 110 | | | | | | | | | |
| New York | (8) | | | | | | | | | | | | | | | | | | |
| North Carolina | 251 | −18 | 233 | 1 | [9] 151 | 4 | 73 | 4 | 77 | 232 | (10) | | | | | | | | |
| North Dakota | 23 | 10 | 33 | 23 | 10 | | | | | 10 | | | | | | | | | |
| Ohio | 492 | 214 | 706 | 108 | 571 | | | | | 571 | 27 | | | 27 | | | | | |
| Oklahoma | 1,271 | −5 | 1,266 | 91 | 843 | | | | | 843 | 332 | | | 332 | | | | | |
| Oregon | 1,094 | −36 | 1,058 | 211 | 443 | 43 | 230 | | 230 | 716 | *124 | | | 124 | 2 | 5 | | | 5 |
| Pennsylvania | 8 | | 8 | | 8 | | | | | 8 | | | | | | | | | |
| Rhode Island | 9 | | 9 | 9 | | | | | | | | | | | | | | | |
| South Carolina | 189 | −54 | 135 | 32 | 93 | | | | | 93 | | 10 | | 10 | | | | | |
| South Dakota | 484 | −15 | 469 | 41 | 423 | | | | | 423 | | | | | 5 | | | | |
| Tennessee | 369 | 2 | 371 | 69 | 234 | | | | | 234 | | | | | | 68 | | | 68 |
| Texas | 109 | | 109 | 102 | 7 | | | | | 7 | | | | | | | | | |
| Utah | 113 | −15 | 98 | 11 | 81 | | | | | 81 | | | | | | 6 | | | 6 |
| Vermont | (8) | | | | | | | | | | | | | | | | | | |
| Virginia | 200 | −3 | 197 | 26 | 135 | | 10 | | 10 | 145 | | | | | | 26 | | | 26 |
| Washington | 245 | | 245 | 245 | | | | | | | | | | | | | | | |
| West Virginia | 91 | | 91 | | 36 | | 55 | | 55 | 91 | | | | | | | | | |
| Wisconsin | 1,559 | −53 | 1,503 | 356 | | | | | | | | | | | | 1,147 | | | 1,147 |
| Wyoming | 227 | −1 | 226 | 33 | 188 | 5 | | | | 193 | | | | | | | | | |
| District of Columbia | 219 | | 219 | | | | | | | | | | | | | 219 | | | 219 |
| Total | 16,216 | 505 | 16,721 | 3,342 | 6,513 | 171 | 700 | 138 | 838 | 7,522 | 1,709 | 10 | 217 | 1,936 | 8 | 3,872 | 35 | 6 | 3,913 |

[1] Amounts distributed during the calendar year often differ from actual collections because of undistributed funds and lag between accounts of collecting and expending agencies.

[2] In many States the proceeds of highway user taxes are placed in a common fund from which a distribution is made. The amounts so distributed have been prorated in proportion to the receipts not otherwise dedicated. See 2 preceding tables.

[3] Approximately $80,000 allotted for use on county roads under State control in North Carolina included in State highway purposes.

[4] Reimbursement to local units of Government for amounts spent on roads now on State system.

[5] In States indicated by star (*) law provides that these funds may also be used for service of local highway obligations. Amounts so used not reported separately. In Colorado funds may be used on both State and local roads

[6] This column shows specific allotments for city streets. Where reported separately, funds allotted for urban extensions of State highway system are included in allotments for State highway purposes.

[7] No special taxes on motor carriers reported

[8] Ton-mile and passenger-mile taxes paid by motor carriers in lieu of registration fees included in motor-vehicle receipts, preceding table.

# DISPOSITION OF RECEIPTS FROM STATE IMPOSTS ON HIGHWAY USERS, 1937

[Compiled for calendar year from reports of State authorities]

| State | Net total receipts of calendar year [1] | Adjustments due to undistributed funds etc.[2] | Tax on aviation gasoline deducted | Net total funds distributed | Expenses of collection and administration[3] | For State highway purposes: Construction, maintenance, and administration [4] | For State highway purposes: State highway police | For State highway purposes: Service of State highway obligations: State highway bonds and notes | For State highway purposes: Service of State highway obligations: State-assumed local obligations [5] | For State highway purposes: Service of State highway obligations: Total | For State highway purposes: Total for State highway purposes | For local roads and streets [6]: For work on county and local roads [4] | For local roads and streets [6]: For work on city streets [7] | For local roads and streets [6]: Service of local highway obligations | For local roads and streets [6]: Total | For other highway purposes (park and forest roads, etc.) | For nonhighway purposes: To general funds [8]: Motor-fuel inspection fees, dealers' licenses, etc. | For nonhighway purposes: To general funds [8]: All other highway user imposts | For nonhighway purposes: For relief of unemployment or destitution | For nonhighway purposes: For education | For nonhighway purposes: For other specific purposes [9] | For nonhighway purposes: Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* | *1,000 dollars* |
| Alabama | 18,005 | 197 | ..... | 18,202 | 680 | 6,439 | 406 | 3,227 | ..... | 3,227 | 10,072 | 6,686 | ..... | ..... | 6,686 | ..... | ..... | 764 | ..... | ..... | ..... | 764 |
| Arizona | 5,638 | −2 | ..... | 5,636 | 344 | 3,847 | 141 | ..... | ..... | ..... | 3,988 | [14]1,297 | ..... | ..... | 1,297 | ..... | ..... | ..... | ..... | ..... | 7 | 7 |
| Arkansas | 13,205 | ..... | ..... | 13,205 | 452 | 3,023 | 130 | 5,958 | 2,833 | 8,791 | 11,944 | 623 | ..... | 104 | 727 | ..... | 82 | ..... | ..... | ..... | ..... | 82 |
| California | 73,675 | −177 | ..... | 73,498 | 3,885 | 30,163 | 2,641 | 3,964 | ..... | 3,964 | 36,768 | [14]19,093 | 3,595 | ..... | 22,688 | ..... | ..... | 10,157 | ..... | ..... | ..... | 10,157 |
| Colorado | 10,655 | −4 | ..... | 10,651 | 731 | 5,664 | 298 | 720 | ..... | 720 | 6,682 | 3,238 | ..... | ..... | 3,238 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Connecticut | 16,398 | −631 | ..... | 15,767 | 1,175 | 8,995 | 325 | ..... | 2,223 | 2,223 | 11,543 | 3,049 | ..... | ..... | 3,049 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Delaware | 3,236 | 75 | ..... | 3,311 | 115 | [4]2,154 | 210 | 65 | 520 | 585 | 2,949 | (14) | 21 | ..... | 21 | 218 | ..... | ..... | ..... | ..... | 8 | 8 |
| Florida | 28,924 | 12 | ..... | 28,936 | 1,139 | 9,123 | 39 | ..... | 3,300 | 3,300 | 12,462 | 113 | 38 | 6,503 | 6,654 | ..... | ..... | 2,542 | ..... | 6,118 | 21 | 8,681 |
| Georgia | 22,073 | 226 | ..... | 22,299 | 975 | 11,329 | 320 | ..... | 2,673 | 2,673 | 14,322 | 3,763 | ..... | ..... | 3,763 | ..... | ..... | ..... | ..... | 3,239 | ..... | 3,239 |
| Idaho | 6,641 | 55 | 6 | 6,690 | 116 | 4,426 | 136 | ..... | ..... | ..... | 4,562 | [14]2,012 | ..... | ..... | 2,012 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Illinois | 57,696 | 464 | ..... | 58,160 | 1,806 | 20,743 | 1,436 | 8,837 | 382 | 9,219 | 31,398 | [14]9,303 | [14]7,970 | ..... | 17,273 | ..... | 168 | 207 | 4,409 | 2,899 | ..... | 7,683 |
| Indiana | 34,006 | 2,838 | ..... | 36,844 | 1,248 | 18,662 | 446 | ..... | ..... | ..... | 19,108 | 10,769 | 2,680 | ..... | 13,449 | ..... | 418 | 2,621 | ..... | ..... | ..... | 3,039 |
| Iowa | 25,502 | 122 | ..... | 25,624 | 1,626 | 9,701 | ..... | ..... | 8,087 | 8,087 | 17,788 | [14]6,210 | ..... | ..... | 6,210 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Kansas | 15,936 | −256 | ..... | 15,680 | 1,433 | 9,167 | 136 | 344 | 1,000 | 1,344 | 10,647 | 3,600 | ..... | ..... | 3,600 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Kentucky | 18,190 | 127 | ..... | 18,317 | 600 | 15,050 | 185 | ..... | ..... | ..... | 15,235 | 657 | ..... | ..... | 657 | ..... | ..... | 1,825 | ..... | ..... | ..... | 1,825 |
| Louisiana | 20,713 | −204 | ..... | 20,509 | 237 | 4,046 | 412 | 7,968 | ..... | 7,968 | 12,426 | ..... | 980 | ..... | 980 | ..... | ..... | ..... | 4,622 | 1,122 | 1,122 | 6,866 |
| Maine | 9,437 | −5 | ..... | 9,432 | 188 | 5,623 | 275 | 2,412 | ..... | 2,412 | 8,310 | 934 | ..... | ..... | 934 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Maryland | 15,434 | −993 | ..... | 14,441 | 612 | 5,623 | 378 | [10]2,563 | ..... | 2,563 | 8,564 | 930 | 3,600 | 735 | 5,265 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Massachusetts | 26,766 | 213 | ..... | 26,979 | 1,720 | 7,281 | 350 | [11]3,243 | ..... | 3,243 | 10,874 | 4,150 | ..... | [11]488 | 4,638 | [11]1,179 | ..... | 6,600 | [11]1,968 | ..... | ..... | 8,568 |
| Michigan | 51,918 | −140 | 50 | 51,728 | 2,150 | 20,302 | 321 | 3,000 | ..... | 3,000 | 23,623 | [14]25,679 | ..... | ..... | 25,679 | ..... | 5 | 271 | ..... | ..... | ..... | 276 |
| Minnesota | 24,383 | 35 | ..... | 24,418 | 600 | 14,265 | 281 | 1,748 | 2,261 | 4,009 | 18,555 | [14]5,098 | ..... | ..... | 5,098 | ..... | 51 | 114 | ..... | ..... | ..... | 165 |
| Mississippi | 12,628 | −4 | ..... | 12,624 | 203 | 3,030 | 38 | 2,562 | ..... | 2,562 | 5,630 | [14]6,338 | ..... | ..... | 6,338 | 453 | ..... | ..... | ..... | ..... | ..... | ..... |
| Missouri | 21,376 | 401 | ..... | 21,777 | 800 | 13,055 | 388 | 7,400 | ..... | 7,400 | 20,843 | 60 | ..... | ..... | 60 | ..... | 74 | ..... | ..... | ..... | ..... | 74 |
| Montana | 6,159 | 152 | ..... | 6,311 | 127 | 4,064 | 159 | 566 | ..... | 566 | 4,789 | 1,354 | 41 | ..... | 1,395 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Nebraska | 13,660 | −159 | 25 | 13,476 | 354 | 6,984 | 75 | ..... | ..... | ..... | 7,059 | [14]4,502 | 331 | ..... | 4,833 | ..... | ..... | 8 | 1,222 | ..... | ..... | 1,230 |
| Nevada | 1,657 | ..... | ..... | 1,657 | 41 | 1,482 | 38 | 87 | 9 | 96 | 1,616 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| New Hampshire | 5,637 | 57 | ..... | 5,694 | 133 | 3,782 | 179 | 829 | ..... | 829 | 4,790 | 461 | ..... | [12]285 | 746 | 25 | ..... | ..... | ..... | ..... | ..... | ..... |
| New Jersey | 40,955 | 163 | ..... | 41,118 | 1,915 | 5,533 | ..... | 7,633 | ..... | 7,633 | 13,166 | 9,256 | ..... | 1,909 | 11,165 | 233 | ..... | ..... | 12,638 | 1,238 | 763 | 14,639 |
| New Mexico | 5,719 | 142 | ..... | 5,861 | 333 | 3,005 | 120 | 1,603 | ..... | 1,603 | 4,728 | 218 | ..... | ..... | 218 | ..... | ..... | 582 | ..... | ..... | ..... | 582 |
| New York [13] | 114,816 | −4,696 | ..... | 110,120 | 3,009 | 24,087 | 1,335 | 10,160 | ..... | 10,160 | 35,582 | [14]19,237 | 6,629 | ..... | 25,866 | 5,690 | ..... | 39,973 | ..... | ..... | ..... | 39,973 |
| North Carolina | 32,499 | −681 | ..... | 31,818 | 502 | [4]19,408 | 612 | 9,429 | 473 | 9,902 | 29,922 | (14) | ..... | ..... | ..... | ..... | 877 | 500 | ..... | ..... | 17 | 1,394 |
| North Dakota | 4,539 | −142 | ..... | 4,397 | 248 | 2,263 | 121 | 251 | ..... | 251 | 2,635 | 1,500 | ..... | ..... | 1,500 | ..... | ..... | 14 | ..... | ..... | ..... | 14 |
| Ohio | 72,665 | 1,983 | ..... | 74,648 | 1,667 | 26,173 | 501 | ..... | ..... | ..... | 26,674 | [14]22,570 | 11,346 | ..... | 33,916 | ..... | ..... | ..... | ..... | 12,017 | 374 | 12,391 |
| Oklahoma | 20,627 | −295 | ..... | 20,332 | 1,560 | 10,351 | 294 | ..... | ..... | ..... | 10,645 | [14]6,269 | ..... | ..... | 6,269 | ..... | 4 | ..... | ..... | ..... | 1,854 | 1,858 |
| Oregon | 14,273 | 8 | 8 | 14,273 | 708 | 7,280 | 350 | 3,784 | ..... | 3,784 | 11,414 | [14]2,031 | ..... | ..... | 2,031 | 45 | ..... | 75 | ..... | ..... | ..... | 75 |
| Pennsylvania | 94,060 | [14]18,888 | ..... | 112,948 | 2,288 | 79,779 | 2,623 | 6,260 | ..... | 6,260 | 88,662 | [14]7,032 | 500 | ..... | 7,532 | 110 | ..... | ..... | 13,854 | ..... | 502 | 14,356 |
| Rhode Island [13] | 5,893 | 93 | ..... | 5,986 | 289 | 2,848 | 146 | 276 | ..... | 276 | 3,270 | 422 | ..... | ..... | 422 | 29 | ..... | 1,976 | ..... | ..... | ..... | 1,976 |
| South Carolina | 13,014 | −45 | 31 | 12,938 | 224 | 5,358 | 282 | 1,736 | 3,332 | 5,068 | 10,708 | [14]1,812 | 10 | ..... | 1,822 | ..... | 184 | ..... | ..... | ..... | ..... | 184 |
| South Dakota | 6,289 | 326 | 3 | 6,612 | 217 | 3,406 | 3 | ..... | ..... | ..... | 3,409 | 1,242 | ..... | ..... | 1,242 | 44 | 38 | ..... | ..... | ..... | 1,662 | 1,700 |
| Tennessee | 23,540 | −666 | 39 | 22,835 | 602 | 6,229 | 443 | 6,815 | 1,211 | 8,026 | 14,698 | 5,041 | ..... | ..... | 5,041 | ..... | 981 | 68 | ..... | ..... | 1,445 | 2,494 |
| Texas | 61,471 | −27 | ..... | 61,444 | 2,057 | 26,781 | 443 | ..... | 10,246 | 10,246 | 37,470 | [14]11,671 | ..... | ..... | 11,671 | ..... | ..... | ..... | ..... | 10,246 | ..... | 10,246 |
| Utah | 4,586 | −187 | 36 | 4,363 | 158 | 3,393 | 144 | 592 | ..... | 592 | 4,129 | ..... | ..... | ..... | ..... | ..... | ..... | 76 | ..... | ..... | ..... | 76 |
| Vermont | 4,733 | 358 | ..... | 5,091 | 90 | 2,530 | 94 | 608 | ..... | 608 | 3,232 | ..... | ..... | 1,759 | 1,759 | 10 | ..... | ..... | ..... | ..... | ..... | ..... |
| Virginia | 22,475 | 32 | ..... | 22,507 | 668 | [4]20,429 | 205 | 903 | ..... | 903 | 21,537 | [4]267 | ..... | ..... | 267 | ..... | ..... | 26 | ..... | ..... | 9 | 35 |
| Washington | 19,929 | 52 | ..... | 19,981 | 618 | 8,555 | 1,490 | [11]119 | 52 | 171 | 10,216 | [14]6,495 | 1,550 | [11]97 | 8,142 | ..... | ..... | ..... | [11]1,005 | ..... | ..... | 1,005 |
| West Virginia | 14,749 | ..... | ..... | 14,749 | 227 | [4]6,947 | 10 | 7,565 | ..... | 7,565 | 14,522 | (14) | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Wisconsin | 34,294 | −162 | ..... | 34,132 | 1,448 | 15,424 | ..... | ..... | 4,102 | 4,102 | 19,526 | 7,015 | 1,109 | ..... | 8,124 | 225 | ..... | 4,809 | ..... | ..... | ..... | 4,809 |
| Wyoming | 3,324 | −5 | 33 | 3,286 | 50 | 2,278 | 64 | 278 | ..... | 278 | 2,620 | 616 | ..... | ..... | 616 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| District of Columbia | 3,829 | −2 | ..... | 3,827 | 161 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 2,724 | ..... | 2,724 | ..... | 8 | 934 | ..... | ..... | ..... | 942 |
| Total | 1,177,827 | 17,536 | [23]1 | 1,195,132 | 42,529 | 530,080 | 19,023 | 113,505 | 42,704 | 156,209 | 705,312 | 222,613 | 43,124 | 11,880 | 277,617 | 8,261 | 2,890 | 74,142 | 39,718 | 36,879 | 7,784 | 161,413 |

[1] Includes receipts from motor-fuel taxes, motor-vehicle fees and fines, and special imposts on motor vehicles operated for hire (motor-carrier taxes). See preceding tables, which give distribution of receipts separately.

[2] Amounts distributed during the calendar year often differ from actual collections because of undistributed funds and lag between accounts of collecting and expending agencies.

[3] Includes expenses of collection and administration of motor-fuel tax, motor-vehicle fees, and motor-carrier taxes, and miscellaneous expenses of motor-vehicle regulation.

[4] The following allotments for construction and maintenance of county roads under State control are included in State highway purposes: Delaware, $409,000; North Carolina, $10,238,000; Virginia, $7,000,000; West Virginia, $2,094,000.

[5] Reimbursement to local units of government for amounts spent on roads now on State system.

[6] In States indicated by star (*) law provides that these funds may also be used for service of local highway obligations. Amounts so used not reported separately. In Colorado funds may be used on both State and local roads.

[7] This column shows specific allotments for city streets. Where reported separately, funds allotted for urban extensions of state highway system are included in allotments for State highway purposes.

[8] To State general funds except in the following States: Alabama, county and municipal general funds; California, general funds of counties and cities, $3,821,000; New Mexico, county general funds, $364,000; Wisconsin, towns, cities, and villages in lieu of personal property tax formerly imposed on motor vehicles, $3,657,000. Allocations to local general funds may have been used in part for highways, but such amounts not reported.

[9] For the following purposes: Arizona, irrigation engineering expenses; Delaware, beach protection; Florida, aviation; Louisiana, harbor improvement; New Jersey, service of institutional construction bonds, $520,000, and Department of Commerce and Navigation, $243,000; North Carolina, State probation commission; Ohio, hospitalization of indigent persons injured in motor-vehicle accidents; Oklahoma, service of general State debt; Pennsylvania, aircraft landing fields, $451,000, and cooperative work other departments, $51,000; South Dakota, payments on real estate bonds; Tennessee, debt service on nonhighway bonds; Virginia, aviation.

[10] Legislative restorations from proceeds of sale of general State bonds were applied to debt service payments, thus reducing amounts necessary from current revenue.

[11] Includes debt service charges on emergency relief bond issues prorated in proportion to use of proceeds for State highway, local road, other highway, and nonhighway purposes.

[12] Service of highway relief bonds, a State obligation incurred for improvement of local roads.

[13] Appropriations for highway purposes out of State general fund have been credited against payments of motor-fuel tax and motor-vehicle fees to the general fund and prorated in proportion to net receipts not otherwise dedicated.

[14] Amounts previously loaned to general fund for relief purposes entirely repaid during 1937.

[illegible] To State general funds except in the following States: Alabama, county and municipal [illegible]; California, general funds of counties and cities, $3,821,000; New Mexico, county general funds, $364,000; Wis-

[illegible] Amounts previously loaned to general funds for [illegible]



# STATUS OF FEDERAL-AID HIGHWAY PROJECTS

## AS OF SEPTEMBER 30, 1938

| STATE | COMPLETED DURING CURRENT FISCAL YEAR | | | UNDER CONSTRUCTION | | | APPROVED FOR CONSTRUCTION | | | BALANCE OF FUNDS AVAILABLE FOR PROGRAMMED PROJECTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | Estimated Total Cost | Federal Aid | Miles | Estimated Total Cost | Federal Aid | Miles | Estimated Total Cost | Federal Aid | Miles | |
| Alabama | $ 1,659,461 | $ 735,930 | 17.6 | $ 8,126,378 | $ 4,053,960 | 344.6 | $ 2,176,494 | $ 1,085,955 | 94.4 | $ 2,875,596 |
| Arizona | 988,010 | 787,011 | 69.3 | 1,289,778 | 941,811 | 44.2 | 194,321 | 120,880 | 4.3 | 1,451,953 |
| Arkansas | 541,415 | 539,727 | 63.1 | 1,733,621 | 1,730,820 | 111.3 | 1,632,270 | 1,630,454 | 97.6 | 1,063,230 |
| California | 2,950,086 | 1,547,565 | 73.9 | 10,179,207 | 5,360,556 | 181.0 | 2,137,333 | 1,140,456 | 49.6 | 1,808,453 |
| Colorado | 1,466,214 | 806,752 | 64.1 | 2,917,207 | 1,605,878 | 73.3 | 920,810 | 511,980 | 31.5 | 1,794,558 |
| Connecticut | | | | 1,350,040 | 660,511 | 14.7 | 244,930 | 120,990 | 2.0 | 1,536,794 |
| Delaware | 75,320 | 37,660 | | 1,010,202 | 500,965 | 23.5 | 231,920 | 115,910 | .2 | 1,184,277 |
| Florida | 480,110 | 240,055 | 15.1 | 3,787,138 | 1,893,569 | 79.7 | 468,000 | 234,000 | .3 | 2,981,176 |
| Georgia | 2,807,740 | 1,398,558 | 147.4 | 5,981,044 | 2,990,522 | 277.9 | 768,970 | 384,485 | 45.1 | 5,527,478 |
| Idaho | 1,299,877 | 775,218 | 116.6 | 1,830,239 | 1,088,878 | 111.4 | | | | 1,134,504 |
| Illinois | 1,782,500 | 908,384 | 48.7 | 11,668,268 | 5,832,370 | 262.2 | 3,149,550 | 1,574,774 | 91.8 | 2,328,326 |
| Indiana | 2,035,190 | 1,017,595 | 55.5 | 4,891,291 | 2,445,645 | 109.0 | 1,793,604 | 896,672 | 36.1 | 2,350,710 |
| Iowa | 2,649,293 | 1,232,519 | 81.0 | 7,195,830 | 3,242,183 | 237.9 | 1,763,024 | 827,300 | 57.2 | 349,747 |
| Kansas | 2,117,710 | 1,058,754 | 104.9 | 5,045,834 | 2,479,217 | 678.3 | 3,602,952 | 1,800,473 | 191.5 | 2,955,696 |
| Kentucky | 2,229,306 | 1,101,911 | 88.4 | 5,150,474 | 2,575,237 | 146.5 | 1,520,780 | 760,390 | 45.4 | 2,073,578 |
| Louisiana | 496,596 | 248,267 | 15.8 | 12,060,405 | 2,403,818 | 52.8 | 1,648,572 | 721,592 | 28.6 | 2,347,042 |
| Maine | 1,911,860 | 955,864 | 45.6 | 1,792,486 | 891,888 | 34.7 | 435,005 | 217,501 | 10.3 | 230,174 |
| Maryland | 308,000 | 154,000 | 5.3 | 1,891,567 | 944,021 | 29.0 | 1,688,981 | 820,830 | 28.3 | 1,670,916 |
| Massachusetts | 567,951 | 283,974 | 3.8 | 2,644,499 | 1,322,246 | 13.5 | 855,151 | 425,990 | 8.9 | 2,316,555 |
| Michigan | 2,790,200 | 1,395,100 | 86.6 | 6,481,208 | 3,168,694 | 124.2 | 1,736,469 | 863,322 | 40.5 | 1,713,365 |
| Minnesota | 567,280 | 256,994 | 10.5 | 7,088,576 | 3,528,072 | 345.5 | 2,123,524 | 1,053,619 | 103.4 | 1,924,238 |
| Mississippi | 759,208 | 352,662 | 31.9 | 8,326,480 | 3,205,471 | 368.9 | 1,409,600 | 351,970 | 71.1 | 3,115,942 |
| Missouri | 2,018,904 | 1,004,195 | 65.1 | 3,985,170 | 1,950,258 | 101.3 | 4,096,238 | 1,778,114 | 159.4 | 3,370,342 |
| Montana | 1,383,975 | 778,153 | 69.4 | 674,888 | 379,264 | 19.4 | 317,839 | 178,783 | 11.0 | 4,363,986 |
| Nebraska | 2,097,633 | 1,048,733 | 248.7 | 6,178,086 | 3,079,442 | 457.8 | 2,070,308 | 401,601 | 52.3 | 2,553,158 |
| Nevada | 1,080,635 | 936,162 | 106.1 | 623,465 | 534,727 | 75.2 | 468,897 | 406,166 | 8.2 | 1,217,185 |
| New Hampshire | 711,007 | 351,969 | 19.8 | 558,750 | 278,256 | 4.9 | 143,230 | 71,614 | 1.5 | 1,138,227 |
| New Jersey | | | | 3,028,331 | 1,511,228 | 21.7 | 305,990 | 152,370 | 3.3 | 2,537,873 |
| New Mexico | 1,157,176 | 705,751 | 145.4 | 1,884,391 | 1,249,455 | 119.5 | 210,862 | 128,604 | 6.6 | 795,787 |
| New York | 4,890,956 | 2,398,750 | 105.1 | 14,251,023 | 7,037,212 | 238.6 | 2,024,030 | 982,665 | 25.0 | 2,817,777 |
| North Carolina | 2,642,358 | 1,304,224 | 136.1 | 6,837,996 | 3,304,827 | 328.2 | 1,769,590 | 873,470 | 95.0 | 1,933,713 |
| North Dakota | 509,340 | 460,000 | 50.2 | 2,889,891 | 2,643,078 | 212.0 | 136,652 | 73,189 | 10.2 | 3,567,977 |
| Ohio | 2,098,470 | 1,047,200 | 28.9 | 8,541,422 | 4,242,300 | 89.8 | 5,579,690 | 2,772,519 | 49.6 | 5,846,598 |
| Oklahoma | 2,390,057 | 1,259,286 | 81.8 | 5,266,416 | 2,748,303 | 185.5 | 1,401,390 | 744,465 | 58.6 | 2,656,311 |
| Oregon | 1,240,688 | 707,212 | 49.2 | 1,747,565 | 1,058,367 | 47.5 | 425,782 | 259,860 | 56.7 | 1,982,244 |
| Pennsylvania | 4,465,212 | 2,230,026 | 74.9 | 5,563,978 | 2,759,958 | 78.3 | 6,560,257 | 3,261,179 | 60.0 | 2,672,558 |
| Rhode Island | 202,800 | 101,400 | 1.7 | 939,242 | 469,621 | 14.3 | 287,710 | 143,855 | 2.1 | 1,028,924 |
| South Carolina | 2,730,437 | 1,209,193 | 152.5 | 3,370,242 | 1,503,432 | 125.8 | 2,003,011 | 900,100 | 56.7 | 1,165,475 |
| South Dakota | 611,862 | 353,755 | 73.9 | 4,089,492 | 2,261,560 | 384.5 | 1,580,520 | 872,770 | 117.3 | 2,720,117 |
| Tennessee | 1,623,080 | 811,540 | 56.0 | 4,868,714 | 2,434,357 | 128.5 | 868,860 | 433,930 | 15.4 | 4,310,972 |
| Texas | 6,823,031 | 3,387,715 | 440.9 | 10,183,495 | 5,046,449 | 509.9 | 4,263,605 | 1,886,002 | 212.5 | 6,275,668 |
| Utah | 725,860 | 521,130 | 102.4 | 1,613,295 | 1,146,535 | 55.2 | 354,730 | 251,750 | 10.0 | 894,864 |
| Vermont | 819,759 | 364,476 | 23.3 | 971,790 | 461,233 | 25.7 | 328,570 | 164,095 | 5.3 | 148,696 |
| Virginia | 2,594,411 | 1,296,500 | 86.2 | 4,646,135 | 2,320,402 | 157.1 | 1,510,354 | 752,827 | 40.0 | 688,815 |
| Washington | 2,249,597 | 1,183,100 | 46.2 | 3,138,123 | 1,644,159 | 45.8 | 804,454 | 423,000 | 13.5 | 828,161 |
| West Virginia | 703,299 | 518,649 | 26.0 | 1,910,644 | 1,203,321 | 57.3 | 708,719 | 342,923 | 9.8 | 2,176,030 |
| Wisconsin | 2,439,158 | 1,161,453 | 72.0 | 6,856,365 | 3,187,350 | 206.9 | 987,244 | 479,920 | 28.8 | 1,551,246 |
| Wyoming | 1,163,657 | 715,911 | 140.0 | 1,377,252 | 845,491 | 154.6 | 238,950 | 147,620 | 24.8 | 670,022 |
| District of Columbia | 369,705 | 184,853 | 6.6 | 1,270,235 | 626,047 | 20.4 | 28,450 | 11,865 | .3 | 1,202,411 |
| Hawaii | | | | 1,128,739 | 562,390 | 20.5 | 28,590 | 14,245 | 1.9 | 657,740 |
| Puerto Rico | | | | | | | | | | |
| TOTALS | 80,226,394 | 41,895,836 | 3,553.5 | 220,836,907 | 109,355,354 | 7,550.3 | 70,007,282 | 34,569,044 | 2,173.9 | 106,510,185 |

# STATUS OF FEDERAL-AID SECONDARY OR FEEDER ROAD PROJECTS

## AS OF SEPTEMBER 30, 1938

| STATE | COMPLETED DURING CURRENT FISCAL YEAR | | | UNDER CONSTRUCTION | | | APPROVED FOR CONSTRUCTION | | | BALANCE OF FUNDS AVAILABLE FOR PROGRAMMED PROJECTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | Estimated Total Cost | Federal Aid | Miles | Estimated Total Cost | Federal Aid | Miles | Estimated Total Cost | Federal Aid | Miles | |
| Alabama | $ 281,361 | $ 187,459 | 18.6 | $ 562,000 | $ 280,700 | 37.8 | $ 82,605 | $ 40,200 | 6.2 | $ 732,072 |
| Arizona | | | | 45,324 | 27,889 | 2.0 | 76,142 | 45,177 | 4.7 | 395,957 |
| Arkansas | | | | 19,426 | 12,863 | | 107,411 | 107,356 | 12.6 | 743,889 |
| California | 392,268 | 226,045 | 34.8 | 1,228,447 | 670,195 | 62.6 | 421,417 | 230,347 | 33.8 | 720,639 |
| Colorado | 425,450 | 236,550 | 31.6 | 417,036 | 230,283 | 19.5 | 88,360 | 32,000 | 4.8 | 422,735 |
| Connecticut | | | | 57,470 | 28,735 | 1.2 | 29,410 | 14,510 | .3 | 275,033 |
| Delaware | | | | | | | 103,704 | 51,852 | 16.9 | 195,023 |
| Florida | | | | 20,122 | 10,061 | | 105,900 | 52,950 | .7 | 611,841 |
| Georgia | 129,537 | 63,897 | 17.6 | 498,260 | 249,130 | 58.4 | 256,080 | 128,040 | 37.1 | 817,655 |
| Idaho | 243,115 | 110,501 | 39.8 | 229,211 | 97,855 | 14.7 | 35,697 | 17,955 | 2.3 | 247,261 |
| Illinois | 553,000 | 276,500 | 44.7 | 1,672,992 | 782,496 | 125.2 | 648,400 | 324,200 | 43.7 | 643,719 |
| Indiana | 56,600 | 24,600 | 9.2 | 772,700 | 334,350 | 76.9 | 1,059,148 | 516,702 | 97.1 | 366,786 |
| | | | | | | | | | | 1,298,449 |
| Iowa | 43,670 | 21,835 | .5 | 67,822 | 33,911 | 7.6 | 268,154 | 134,076 | 48.4 | 1,129,149 |
| Kansas | | | | | | | | | | |
| Kentucky | 309,086 | 104,551 | 52.0 | 630,278 | 186,311 | 50.4 | 1,262,037 | 335,098 | 94.9 | 188,466 |
| Louisiana | | | | 155,231 | 72,985 | 11.6 | 878,653 | 371,430 | 75.4 | 279,721 |
| Maine | 174,400 | 87,200 | 11.0 | 327,126 | 163,563 | 19.7 | 138,600 | 63,433 | 6.0 | 14,377 |
| Maryland | | | | 6,264 | 3,132 | | 84,800 | 29,605 | 8.7 | 379,739 |
| Massachusetts | | | | 5,300 | 2,650 | | 143,050 | 71,315 | 2.4 | 572,435 |
| Michigan | | | | 616,866 | 308,433 | 46.1 | 305,290 | 152,645 | 25.8 | 1,074,461 |
| Minnesota | 130,131 | 61,694 | 21.3 | 321,169 | 151,900 | 24.9 | 318,140 | 158,740 | 40.0 | 1,007,246 |
| Mississippi | | | | 104,800 | 52,400 | 4.0 | 194,200 | 97,100 | 19.8 | 739,427 |
| Missouri | 224,357 | 111,427 | 34.3 | 231,370 | 115,290 | 15.3 | 616,650 | 225,705 | 84.1 | 612,827 |
| Montana | | | | 13,983 | 7,865 | | | | | 1,027,170 |
| Nebraska | 149,082 | 74,541 | 21.6 | 451,070 | 225,535 | 72.9 | 247,552 | 120,556 | 47.4 | 575,420 |
| Nevada | 228,041 | 194,840 | 30.8 | 119,166 | 100,152 | 32.7 | 94,427 | 81,932 | 22.1 | 117,369 |
| New Hampshire | 97,426 | 48,277 | 1.7 | 111,335 | 55,301 | 2.8 | 39,820 | 19,880 | 1.5 | 123,417 |
| New Jersey | | | | 123,040 | 61,520 | 2.4 | 223,920 | 103,630 | 2.7 | 507,623 |
| New Mexico | 289,750 | 176,717 | 14.4 | 327,188 | 190,070 | 22.5 | 299,156 | 162,318 | 15.2 | 277,667 |
| New York | 1,484,731 | 739,812 | 102.8 | 1,420,300 | 692,550 | 94.6 | 1,101,600 | 469,450 | 42.2 | 458,403 |
| North Carolina | 54,380 | 27,190 | 10.1 | 1,004,664 | 502,310 | 97.0 | 293,440 | 136,520 | 19.6 | 415,835 |
| North Dakota | | | | 106,900 | 57,253 | 26.8 | 91,100 | 48,792 | 16.2 | 681,207 |
| Ohio | | | | 184,400 | 92,200 | 3.8 | 60,600 | 29,750 | 1.8 | 1,709,691 |
| Oklahoma | 12,200 | 6,491 | | 396,738 | 209,979 | 34.2 | 449,030 | 215,734 | 29.9 | 752,711 |
| Oregon | 279,315 | 169,410 | 41.7 | 152,117 | 92,122 | 9.3 | 60,504 | 28,000 | 6.6 | 463,622 |
| Pennsylvania | 758,719 | 369,060 | 54.8 | 1,201,117 | 581,021 | 73.0 | 1,347,074 | 654,837 | 72.8 | 510,970 |
| Rhode Island | 66,840 | 33,420 | 3.5 | 68,848 | 34,424 | 2.6 | 187,830 | 93,915 | 3.1 | 26,132 |
| South Carolina | 50,120 | 22,700 | 6.6 | 752,519 | 319,662 | 84.9 | 482,027 | 191,400 | 46.6 | 141,918 |
| South Dakota | | | | 11,300 | 6,250 | | | | | 816,436 |
| Tennessee | 53,200 | 26,600 | 1.3 | 400,886 | 184,973 | 23.4 | 275,920 | 101,810 | 14.6 | 746,107 |
| Texas | 690,705 | 313,110 | 122.6 | 2,070,709 | 919,140 | 220.8 | 734,944 | 306,775 | 111.0 | 1,585,744 |
| Utah | 226,240 | 125,370 | 28.1 | 372,398 | 177,140 | 24.8 | 170,330 | 75,400 | 26.9 | 172,460 |
| Vermont | 163,580 | 71,150 | 9.7 | 101,376 | 49,153 | 4.8 | 114,700 | 56,200 | 3.8 | 33,093 |
| Virginia | 255,430 | 125,500 | 28.8 | 728,647 | 315,041 | 53.1 | 243,230 | 113,931 | 20.6 | 337,527 |
| Washington | 266,218 | 139,900 | 19.9 | 310,853 | 163,278 | 42.2 | 395,197 | 208,000 | 24.6 | 219,378 |
| West Virginia | 28,900 | 14,450 | 1.4 | 215,150 | 107,575 | 20.0 | 122,300 | 61,150 | 6.2 | 366,499 |
| Wisconsin | 46,947 | 23,405 | 1.4 | 924,481 | 441,190 | 38.5 | 252,117 | 115,380 | 14.4 | 632,253 |
| Wyoming | 290,340 | 179,400 | 33.7 | 333,680 | 206,180 | 20.9 | 124,440 | 76,890 | 14.0 | 122,723 |
| District of Columbia | | | | 56,250 | 28,125 | 2.4 | | | | 218,750 |
| Hawaii | | | | 244,000 | 121,950 | 13.7 | 35,610 | 17,455 | 1.5 | 107,470 |
| Puerto Rico | | | | | | | | | | |
| TOTALS | 8,455,439 | 4,393,602 | 853.3 | 20,192,329 | 9,757,091 | 1,602.0 | 14,670,716 | 6,690,141 | 1,231.0 | 26,619,502 |

U. S. GOVERNMENT PRINTING OFFICE : 19

# *PUBLICATIONS of the BUREAU OF PUBLIC ROADS*

Any of the following publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. As his office is not connected with the Department and as the Department does not sell publications, please send no remittance to the United States Department of Agriculture.

## *ANNUAL REPORTS*

Report of the Chief of the Bureau of Public Roads, 1931. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1933. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1934. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1935. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1936. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1937. 10 cents.

## *HOUSE DOCUMENT NO. 462*

Part 1 . . . Nonuniformity of State Motor-Vehicle Traffic Laws. 15 cents.

Part 2 . . . Skilled Investigation at the Scene of the Accident Needed to Develop Causes. 10 cents.

Part 3 . . . Inadequacy of State Motor-Vehicle Accident Reporting. 10 cents.

Part 4 . . . Official Inspection of Vehicles. 10 cents.

Part 5 . . . Case Histories of Fatal Highway Accidents. 10 cents.

Part 6 . . . The Accident-Prone Driver. 10 cents.

## *MISCELLANEOUS PUBLICATIONS*

No. 76MP . . The Results of Physical Tests of Road-Building Rock. 10 cents.

No. 191MP . . Roadside Improvement. 10 cents.

No. 272MP . . Construction of Private Driveways. 10 cents.

No. 279MP . . Bibliography on Highway Lighting. 5 cents.

Highway Accidents. 10 cents.

The Taxation of Motor Vehicles in 1932. 35 cents.

Guides to Traffic Safety. 10 cents.

Federal Legislation and Rules and Regulations Relating to Highway Construction. 15 cents.

An Economic and Statistical Analysis of Highway-Construction Expenditures. 15 cents.

Highway Bond Calculations. 10 cents.

## *DEPARTMENT BULLETINS*

No. 1279D . . Rural Highway Mileage, Income, and Expenditures, 1921 and 1922. 15 cents.

No. 1486D . . Highway Bridge Location. 15 cents.

## *TECHNICAL BULLETINS*

No. 55T . . . Highway Bridge Surveys. 20 cents.

No. 265T . . . Electrical Equipment on Movable Bridges. 35 cents.

---

Single copies of the following publications may be obtained from the Bureau of Public Roads upon request. They cannot be purchased from the Superintendent of Documents.

## *MISCELLANEOUS PUBLICATIONS*

No. 296MP . . . Bibliography on Highway Safety.

## *SEPARATE REPRINT FROM THE YEARBOOK*

No. 1036Y . . Road Work on Farm Outlets Needs Skill and Right Equipment.

## *TRANSPORTATION SURVEY REPORTS*

Report of a Survey of Transportation on the State Highway System of Ohio (1927).

Report of a Survey of Transportation on the State Highways of Vermont (1927).

Report of a Survey of Transportation on the State Highways of New Hampshire (1927).

Report of a Plan of Highway Improvement in the Regional Area of Cleveland, Ohio (1928).

Report of a Survey of Transportation on the State Highways of Pennsylvania (1928).

Report of a Survey of Traffic on the Federal-Aid Highway Systems of Eleven Western States (1930).

## *UNIFORM VEHICLE CODE*

Act I.—Uniform Motor Vehicle Administration, Registration, Certificate of Title, and Antitheft Act.

Act II.—Uniform Motor Vehicle Operators' and Chauffeurs' License Act.

Act III.—Uniform Motor Vehicle Civil Liability Act.

Act IV.—Uniform Motor Vehicle Safety Responsibility Act.

Act V.—Uniform Act Regulating Traffic on Highways.

Model Traffic Ordinances.

---

A complete list of the publications of the Bureau of Public Roads, classified according to subject and including the more important articles in PUBLIC ROADS, may be obtained upon request addressed to the U. S. Bureau of Public Roads, Willard Building, Washington, D. C.

# STATUS OF FEDERAL-AID GRADE CROSSING PROJECTS

## AS OF SEPTEMBER 30, 1938

| STATE | COMPLETED DURING CURRENT FISCAL YEAR | | | | | UNDER CONSTRUCTION | | | | | APPROVED FOR CONSTRUCTION | | | | | BALANCE OF FUNDS AVAILABLE FOR PROGRAMMED PROJECTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimated Total Cost | Federal Aid | NUMBER | | | Estimated Total Cost | Federal Aid | NUMBER | | | Estimated Total Cost | Federal Aid | NUMBER | | | |
| | | | Grade Crossings Eliminated by Separation or Relocation | Grade Crossing Structures Reconstructed | Grade Crossings Protected by Signals or Otherwise | | | Grade Crossings Eliminated by Separation or Relocation | Grade Crossing Structures Reconstructed | Grade Crossings Protected by Signals or Otherwise | | | Grade Crossings Eliminated by Separation or Relocation | Grade Crossing Structures Reconstructed | Grade Crossings Protected by Signals or Otherwise | |
| Alabama | $ 153,610 | $ 153,610 | 4 | | 4 | $ 502,248 | $ 501,224 | 5 | | | $ 548,900 | $ 548,400 | 6 | | 3 | $ 782,285 |
| Arizona | | | | | | 9,452 | 9,452 | | | | | | | | | 620,761 |
| Arkansas | | | | | | 425,535 | 424,296 | 10 | | | 209,841 | 209,472 | 4 | | | 1,125,001 |
| California | 366,760 | 366,760 | | 2 | | 1,086,983 | 1,086,408 | 5 | 2 | | 326,626 | 317,154 | 3 | | | 1,929,887 |
| Colorado | 17,980 | 17,979 | 1 | | 1 | 71,588 | 71,588 | 1 | | | 25,042 | 21,282 | | | 10 | 1,177,463 |
| Connecticut | | | | | | | | | | | | | | | | 844,490 |
| Delaware | | | | | | | | | | | 77,270 | 77,270 | | | 23 | 416,480 |
| Florida | | | | | | 10,616 | 10,616 | | | | 391,900 | 391,900 | 3 | | | 1,003,281 |
| Georgia | | | | | | 18,346 | 18,346 | | | | 362,690 | 362,690 | 6 | | | 2,036,351 |
| Idaho | 87,825 | 87,652 | 1 | | | 12,342 | 12,342 | | | | 250,314 | 250,314 | 6 | | | 472,562 |
| Illinois | 186,500 | 186,500 | 1 | | 1 | 1,544,675 | 1,544,675 | 5 | 2 | | 660,230 | 660,230 | 6 | | 60 | 2,813,238 |
| Indiana | 314,886 | 228,900 | 1 | 3 | | 555,600 | 528,700 | 4 | 2 | | 689,780 | 689,780 | 1 | 1 | 89 | 966,769 |
| Iowa | 527,765 | 498,900 | 4 | | 9 | 694,219 | 653,600 | 7 | 1 | 5 | 48,001 | 44,400 | | 2 | 7 | 1,365,724 |
| Kansas | 326,940 | 326,940 | 7 | | 4 | 506,321 | 506,321 | 6 | | | 360,123 | 360,123 | 6 | | 7 | 1,381,124 |
| Kentucky | 145,000 | 145,000 | 1 | | | 51,100 | 51,100 | 1 | | | 548,746 | 548,746 | 5 | 2 | 31 | 1,069,199 |
| Louisiana | | | | | | 225,285 | 196,478 | 3 | | | 248,872 | 248,090 | 9 | | | 1,132,503 |
| Maine | 48,590 | 48,590 | 2 | | | 327,315 | 327,315 | 3 | 2 | | 2,610 | 2,610 | | | 1 | 312,688 |
| Maryland | | | | | | 64,586 | 64,586 | 1 | | | | | | | | 962,247 |
| Massachusetts | | | | | | 122,260 | 118,859 | | 2 | | 279,660 | 279,550 | 1 | 1 | | 1,514,879 |
| Michigan | 393,000 | 393,000 | 5 | 1 | 7 | 912,458 | 912,458 | 6 | | 38 | 238,600 | 238,600 | 3 | 1 | | 1,741,127 |
| Minnesota | 40,218 | 40,218 | | 1 | 1 | 770,180 | 770,180 | 3 | 5 | | | | | | | 1,614,049 |
| Mississippi | | | | | | 355,700 | 355,700 | 4 | | | 363,800 | 363,800 | 3 | | | 864,651 |
| Missouri | 128,120 | 128,120 | 2 | 1 | | 223,970 | 223,970 | 2 | | | 380,320 | 380,320 | 2 | | | 2,292,643 |
| Montana | 248,112 | 243,230 | 3 | | | 569,521 | 569,521 | 5 | | | | | | | | 511,720 |
| Nebraska | 29,220 | 29,220 | 1 | | | 296,443 | 296,443 | 12 | | | 497,755 | 497,755 | 5 | | 28 | 940,992 |
| Nevada | 97,187 | 97,187 | | 2 | 2 | | | | | | 57,561 | 57,561 | | 1 | 2 | 303,893 |
| New Hampshire | 61,732 | 61,425 | | 1 | | 7,406 | 7,406 | | | | 86,061 | 86,022 | 5 | | | 338,897 |
| New Jersey | | | | | | 210,005 | 204,778 | 2 | 1 | | 130,800 | 130,800 | | 1 | 2 | 1,634,678 |
| New Mexico | | | | | | 200,118 | 200,118 | 4 | 1 | | 128,355 | 128,355 | 3 | | | 523,018 |
| New York | 141,400 | 141,400 | | 1 | 2 | 2,472,972 | 2,417,071 | 9 | 7 | | 214,000 | 183,150 | | 2 | | 4,028,308 |
| North Carolina | 73,550 | 73,550 | | 1 | | 470,810 | 470,810 | 5 | 1 | | 608,330 | 575,630 | 3 | 4 | 11 | 1,324,404 |
| North Dakota | | | | | | 606,278 | 606,278 | 2 | 2 | | | | | | | 972,943 |
| Ohio | | | | | | 103,830 | 103,830 | 2 | | | 465,700 | 465,700 | 5 | | | 3,659,638 |
| Oklahoma | | | | | | 17,343 | 17,343 | | | | 52,075 | 52,075 | | | 14 | 2,212,091 |
| Oregon | 95,263 | 94,614 | | 2 | | 220,687 | 220,687 | 1 | | | 51,075 | 51,075 | | | | 608,955 |
| Pennsylvania | 138,043 | 122,837 | 1 | | | 161,073 | 161,073 | 1 | | | 200,021 | 191,000 | 1 | | | 5,257,625 |
| Rhode Island | | | | | | 314,484 | 314,484 | 1 | 2 | | 20,535 | 20,535 | | 1 | | 158,731 |
| South Carolina | | | | | | 86,379 | 63,593 | 1 | 2 | | 272,740 | 222,140 | 12 | | 34 | 1,203,369 |
| South Dakota | 7,530 | 7,530 | | | 2 | 316,708 | 314,568 | 2 | 2 | 7 | 105,850 | 105,850 | 5 | | 1 | 891,343 |
| Tennessee | | | | | | 14,381 | 14,381 | | | | 87,380 | 87,380 | | 2 | 1 | 1,790,272 |
| Texas | 36,660 | 35,990 | 2 | | | 928,672 | 928,672 | 8 | 2 | | 389,767 | 389,155 | 5 | 1 | | 3,987,972 |
| Utah | 1,760 | 1,760 | | | 1 | 142,818 | 142,818 | 4 | | | 5,319 | 5,319 | | | 3 | 423,166 |
| Vermont | 202,882 | 197,882 | 6 | 1 | | 27,454 | 27,454 | | 1 | | 24,470 | 24,470 | | | 9 | 230,321 |
| Virginia | 245,670 | 245,670 | 12 | 1 | | 241,018 | 241,018 | 3 | 1 | | 304,555 | 304,555 | 3 | | 8 | 1,004,787 |
| Washington | 149,718 | 147,618 | 1 | 2 | 2 | 613,457 | 613,457 | 7 | 2 | | 31,117 | 31,117 | | | 7 | 591,609 |
| West Virginia | 120,100 | 119,080 | 1 | | | 291,909 | 291,909 | 3 | | | 60,870 | 60,870 | 2 | | 5 | 852,239 |
| Wisconsin | 100,586 | 100,586 | 1 | | | 1,110,736 | 1,068,297 | 10 | | | 210,283 | 155,538 | 1 | | | 1,149,088 |
| Wyoming | | | | | | 161,544 | 161,544 | | 2 | 1 | 12,410 | 12,410 | | | 5 | 502,776 |
| District of Columbia | | | | | | | | | | | 34,262 | 34,262 | | 1 | | 291,169 |
| Hawaii | | | | | | 33,230 | 33,230 | 1 | | | 152,570 | 152,570 | 2 | 1 | | 307,950 |
| Puerto Rico | | | | | | 110,940 | 110,390 | 3 | | | 116,096 | 115,440 | 1 | | | 504,470 |
| TOTALS | 4,486,607 | 4,341,748 | 57 | 19 | 36 | 18,220,995 | 17,989,387 | 152 | 42 | 51 | 10,333,302 | 10,135,465 | 117 | 21 | 361 | 64,646,026 |